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REPORT

OF THE

TRANSPORTATION LIBRARY

U.S. BOARD OF ENGINEERS ON DEEP WATERWAYS

BETWEEN THE

GREAT LAKES AND THE ATLANTIC TIDE WATERS.

IN TWO PARTS, WITH ATLAS.

PART II.

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APPENDIXES.

(CONTINUED.)

APPENDIX NO. 16.

REPORT ON SPECIAL WATER-SUPPLY INVESTIGATION.

AUGUST 1, 1899.

GENTLEMEN: Work was begun on the water-supply investigation for projected summit-level canals in the State of New York on August 1, 1898, the arrangement with your Board being that the author give the matter about one-half of his time. It was also understood that the work be completed in one year. The total time devoted to supervising and directing the work and to preparation of report has included, to August 1, 1899, 208 days. The report herewith submitted, with maps, plans, and estimates, is the best effort of which the author is capable with the foregoing limitation of time.

Problems to be studied, included in general terms, consideration of water supplies for the various summit-level canals in the State of New York, not only by the Oswego-Mohawk route, but by the St. Lawrence-Champlain route as well. However, the investigation as to canal routes proper has rendered an extended study of the water supply of a summit level-canal connecting Lake Champlain and Hudson River unnecessary, and the work herein reported upon is, therefore, mostly confined to consideration of water supply for Oswego-Mohawk route.

SOURCES FROM WHICH WATER SUPPLIES FOR OSWEGO-MOHAWK ROUTE MAY BE DRAWN.

A preliminary study of existing conditions indicated that aside from streams immediately tributary to Mohawk River and Oneida Lake, a water supply for summit level of Oswego-Mohawk route must be drawn either from Black River or Lake Erie. The author understood, however, your Board to have decided that Lake Erie was out of consideration because of the peculiar wording of the act of Congress authorizing this investigation, thus limiting the scope of the inquiry to Black River and contiguous streams.[1]

In the study as made, a few streams tributary to Lake Ontario, but which have been intercepted by the proposed Black River feeder, have been included. On this point refer to plate 93.

A small emergency supply may also be drawn from a group of reservoirs on Susquehanna-Mohawk divide, originally constructed by the State of New York for supply of summit level of Chenango Canal.

The water now available for water supply of Rome level of Erie Canal, west of Fort Bull, would also be available for deep waterways, provided satisfactory arrangements were made with the State of New York. As, however, this is at best only a small quantity, it has been, so far as the present discussion is concerned, left out of the account.

RECONNOISSANCE.

In order to gain a clear view of the nature of the problems to be studied by actual inspection of the ground, a reconnoissance was started from Forestport August 14, 1898, examining first the present feeder of the summit level of Black River Canal, which extends from

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[1] (Note by the author, January 15, 1900.) In regard to Lake Erie as a source of water supply for Oswego-Mohawk summit level, the brief statement may be made that during August–November, 1899, the author was engaged on a study of proposed rectification of Erie Canal between Newark and west end of Rome level. The object of this study was to ascertain whether a continuously descending canal could be constructed between the points mentioned, thereby avoiding the present descent to Montezuma and Syracuse levels, with the corresponding ascent to Rome level. The ground traversed by this rectification is the same as would be occupied by a feeder for Oswego-Mohawk summit from Lake Erie. The detail of this study is embodied in a report to the canal committee of the State of New York, and will be published in the annual report of the State engineer and surveyor for 1900. This report is accompanied by topographical maps of the region, which have been constructed from the field sheets of the United States Geological Survey, at a scale of 1: 45,000. These maps show the difficulties to be met between Newark and Rome level by either a canal or feeder construction. Without going into detail at this time, it is sufficient to state that a new canal on the most satisfactory line, 12 feet deep, and with about 1,200 square feet section area, is estimated to cost, for 58 miles, more than the entire cost of a feeder from Black and Salmon rivers, as given in detail further on in this report.

It is probable, however, that a feeder line purely of sufficient capacity to deliver 1,600 cubic feet per second to Rome summit level, would be somewhat less expensive per unit of length, but inasmuch as the total distance from Lake Erie to the point of delivery on Oswego-Mohawk summit, near Fort Bull, is about four times as great as the section actually estimated upon, it is at once apparent that the cost of Lake Erie supply becomes so much greater than Black River supply as to preclude its adoption. A survey to Lake Erie would therefore have no other effect than to emphasize the fact, that as a matter of economic construction a water supply for Oswego-Mohawk summit level must be chiefly drawn from Black and Salmon rivers and the adjacent small streams, as exhibited in detail in the following pages.

Black River at Forestport to the canal at Boonville, a distance of 10.5 miles, and delivers water into Black River Canal at an elevation of 1,119.96 feet above tide water. The elevation of crest of Black River dam at Forestport is 1,126.06 feet above tide water. The present feeder has a capacity of about 225 to 275 cubic feet per second. The catchment area of Black River above Forestport was also examined with reference to the possibility of constructing additional reservoirs on that area. The result of this examination was to show that the available storage of Black River area above Forestport is already substantially utilized by the State reservoirs now existing in that region. Additional storage could only be made there at large expense, although it may be assumed, if the deep waterways are built, that Erie Canal through Mohawk Valley will be abandoned, as would also Black River Canal. Hence, the water now used for the supply of Erie and Black River canals would become available for deep waterways. Nevertheless, it is true that an adequate storage can not be made on upper Black River. The reconnoissance showed, however, that it was practicable to divert Moose River at McKeever through Otter and White lakes into main Black River above Forestport, thus making it possible to deliver that portion of Moose River catchment area, as well as upper Black River at Boonville, where, at a distance of about a mile to the south, the water could be turned into Lansing Kill, a tributary of upper Mohawk, and so delivered directly to proposed deep waterways summit level at Rome.

The diversion of Moose River would be accomplished by means of a dam across that stream just below McKeever and the cutting of a canal through to Otter Lake, a distance of about 1 mile. A connecting channel would lead from Otter Lake to Long Lake, a distance of about 1.5 miles, following generally the course of the present outlet of Otter Lake. From Long Lake a cut would be made through an intervening ridge 60 feet in height for a distance of 2,000 feet, connecting Long Lake with White Lake, from whence the water would flow through the outlet of White Lake to Black River and thence to Forestport, where the present feeder of Black River Canal could be utilized, or a new feeder constructed, as might appear best on detailed examination.

Rapid computation showed, however, that there was no prospect of making a sufficient storage either on Black River above Forestport, or on Moose River above McKeever. The State reservoirs already constructed in that region, while mostly not developed to full capacity, are still so far short of furnishing the quantity of water required for supply of summit level as to make them hardly worth taking into account.

The following are the reservoirs on headwaters of main Black and Moose rivers:

Name of reservoir.	Approximate area.	Approximate mean depth.	Approximate and available capacity.
	Acres.	*Feet.*	*Cubic feet.*
White Lake	298	5	64,000,000
Chub Lake	200	4	35,000,000
Sand Lake	306	15	200,000,000
Woodhull Lake	1,118	18	438,000,000
Bisbys Lakes[a]		3.5	40,000,000
Canachagala Lake	320	4	56,000,000
North Lake	277	28	676,000,000
South Lake	372	26	350,000,000
Twin Lakes	175	8	60,000,000
Fulton Chain Lakes			800,000,000
Forestport	700	10	300,000,000
Total			3,019,000,000

[a] The Bisbys Lakes were abandoned as canal reservoirs by chapter 274 of the laws of 1889.

It may be remarked that there is a compensation State reservoir on Beaver River, the most northerly main tributary of Black River, at Stillwater, with capacity of 800,000,000 cubic feet. Adding this quantity to the preceding, we already have a total artificial storage on Black River of 3,819,000,000 cubic feet.

It has been commonly assumed that extensive storage could be made on the upper reaches of Black River, but when the ground was examined with reference to a supply for deep waterways it was found not nearly as extensive as had been previously assumed. This fact being clearly ascertained, attention was then turned to lower Black River. From Forestport to Port Leyden the stream flows through a broad, sandy valley with no rock showing at the sides, although at several places it appears in the bed of the stream. For this reach of river an extensive barrage is impossible, except at great cost. The ends of a dam would necessarily penetrate a long distance into the sand hills at the sides with deep core walls down on bed rock. Above Port Leyden the rock is, so far as observed, limestone, but at that place the granitic rocks of the Adirondack region appear. At Lyons Falls there is a nearly vertical fall of 68 feet. Below this place, which is the northerly end of Black River Canal, the long stretch of still water extending to Carthage begins. The valley gradually widens out until a width of from 2 to 6 miles is attained in places. A dam at Carthage 48.5 feet in height will flood about 75 square miles and impound over 56,000,000,000 cubic feet of water. The reconnoissance having developed this general fact, it appeared probable that the proper place for a large storage on Black River was at Carthage, provided a practicable way could be found for delivering the stored water into proposed summit level in vicinity of Rome. Continuing the reconnoissance, it appeared that the delivery could be accomplished in two ways—either by the construction of a feeder line following the contour from Carthage around the western slope of the high land of Lewis, Jefferson, Oswego, and Oneida counties to a convenient point in the vicinity of Rome, or by a tunnel 21 miles in length through the intervening ridge from the foot of Lyons Falls to Northwestern, a point on Black River Canal in valley of Upper Mohawk. The broad features of these projects are shown by plate 93. On referring the matter to your Board it was decided to investigate in detail the feeder line from Carthage around slope of hill, preparing only such estimates of cost on the tunnel as could be made without special investigation. This point having been settled by your Board, the preliminary surveys of the feeder line were begun August 25, the work being under the personal charge of J. Y. McClintock, C. E., who was selected as principal assistant.

In the meantime other parties were organized and gaugings of a large number of streams tributary to Mohawk River and Oneida Lake were instituted, the object of such gaugings being to obtain information as to both high and low water flow of these streams. The results of the gaugings from September to May, inclusive, are presented further on.

The proposed Black River feeder presents a novel feature in this, that the topography is such as to permit of utilizing a considerable extent of natural channel, as may be appreciated by reference to plate 93, where the more important utilization on this line is shown.

The following tabulation gives the relative proportions of natural and artificial channel on this feeder:

	Miles.
Natural channel	49.19
Artificial channel	43.56
Total length of feeder	92.75

Further study of the water supply problem indicated the desirability of having a considerable body of water available and not too far away from the main summit level of deep waterway. On this line reservoir sites have been investigated on Fish Creek, near Blossvale (Taberg Station), and on the same stream just above the village of Camden, as well as on Salmon River above High Falls. The topographical condition in Fish Creek Valley are favorable at both the localities examined, but the borings indicate foundations of from 80 to 90 feet deep in quicksand. In view of this adverse condition the Fish Creek sites have been left undeveloped, but that on Salmon River has been developed as possibly an important auxiliary to the water supply.

The foregoing indicates the broad lines of study required to determine a proper water supply for the deep waterways summit levels. In the report much of the detail is omitted, only such being presented as appears necessary for a clear understanding of each section. The following may be taken as a general summary of the work done:

(1) Survey of proposed Black River feeder from Carthage to near Fort Bull, a distance of 92.7 miles.

(2) Survey of proposed Black River reservoir site in Black River Valley from Carthage to Lyons Falls.

(3) Survey of Salmon River reservoir site.

(4) Survey of two reservoir sites on West Branch of Fish Creek.

(5) General examination as to flood reservoirs in the valleys of West Canada, East Canada, and Schoharie creeks.

(6) The establishing of continuous daily gaugings of Mohawk, Oswego, Seneca, Black, and Hudson rivers, and of streams tributary to Mohawk River and Oneida Lake.

(7) A study of existing information relating to flood flows over dams having indicated the necessity for more accurate knowledge, an extended series of experiments have been made at the Cornell University hydraulic laboratory. The results of these experiments, as presented herewith, are believed to be unique in this, that they extend definite information as to flow over weirs of various profiles considerably beyond previous limits.

(8) A number of special studies have been made relating to hydrology, canal and tunnel construction, and which are, so far as necessary for full understanding, embodied in this report.

CATCHMENT AREAS AND MAPS.

There being no satisfactory catchment area maps of Hudson, Mohawk, and Black rivers and Oneida Lake catchment areas (to be considered in this study), it became necessary to prepare such maps. Plates 94, 95, 96, and 97 present maps of these main catchment areas, while the several small areas tributary to the proposed Black River feeder are shown on plate 93. The following are the main subdivisions of the various areas considered:

HUDSON RIVER CATCHMENT AREA.

	Square miles.
Hudson River, above mouth of Mohawk	4,627.0
Hudson River, above Mechanicville	4,506.7
Hudson River, above Hadley	1,678.7
Hoosick River, above mouth	710.6
Batten Kill River, above mouth	437.5
Sacundaga River, above mouth	1,056.5
Schroon River, above mouth	570.0
Schroon River, above gauging station	565.0

MOHAWK RIVER CATCHMENT AREA.

Mohawk River, above mouth	3,468.1
Mohawk River, above Rexford Flats	3,384.9
Mohawk River, above Little Falls	1,306.0
Mohawk River, above Ridge Mills	152.5
Schoharie Creek, above mouth	947.0
Schoharie Creek, above gauging station	946.7
Cayadutta Creek, above mouth	62.2
Cayadutta Creek, above gauging station	40.0
Garoga Creek, above mouth	89.3

	Square miles.
Garoga Creek, above gauging station	80.8
East Canada Creek, above mouth	282.6
East Canada Creek, above gauging station	255.6
West Canada Creek, above mouth	568.7
West Canada Creek, above gauging station	518.7
Saquoit Creek, above mouth	67.2
Saquoit Creek, above gauging station	51.5
Oriskany Creek, above mouth	146.1
Oriskany Creek, above lower gauging station (at Oriskany)	144.3
Oriskany Creek, above upper gauging station (at Colmans)	140.7
Nine Mile Creek, at mouth	73.6
Nine Mile Creek, at gauging station	62.6
Area on north side of Mohawk River, between West Canada and Nine Mile creeks, including Crane Creek, Reels Creek, Knapp Brook, Budlong Creek, Sterling Creek, Bridenbacker Creek, and adjacent territory	85.7
Area on north side of Mohawk River, between West Canada Creek and Little Falls, including Beaver Brook and adjacent territory	15.5
Area on south side of Mohawk River, between Sauquoit Creek and Little Falls, including Ballou Creek, Factory Creek, Ferguson Creek, Moyer Creek, Steele Creek, Fulmer Creek, and adjacent territory	139.1
Six Mile Creek and adjacent area to east of that creek	54.5

BLACK RIVER CATCHMENT AREA.

Black River, above mouth	1,930.2
Black River, above Watertown (Remington dam)	1,891.7
Black River, above Watertown (Huntingtonville dam)	1,888.6
Black River, above Black River Village (Huntington's dam)	1,868.9
Black River, above Rawson's dam (4 miles below Carthage)	1,824.1
Black River, above Carthage (State dam)	1,812.1
Black River, above Forestport	268.0
Black River, at mouth of Moose River, but not including Moose River area	463.0
Deer River, above mouth	102.0
Deer River, above Deer River Village	100.8
Beaver River, above mouth	337.5
Beaver River, above Beaver Falls	322.3
Moose River, above mouth	415.5
Moose River, above Agar's paper mill	407.3
Woodhull Creek, above mouth	108.4
Otter Creek, above Casler's dam (one-half mile above mouth of creek)	63.0
Independence Creek, at mouth	98.8
Independence Creek, at dam (3 miles above mouth)	93.2

OSWEGO RIVER CATCHMENT AREA.

Oswego River, above mouth	5,001.8
Oswego River, above gauging station (Fulton)	4,915.6
Seneca River, above mouth of Oneida River	3,433.1
Seneca River, above gauging station (Baldwinsville)	3,103.0
Oswego River, below mouth of Oneida River	167.1
Oswego River, between Fulton and Three Rivers Point	81.0

ONEIDA RIVER CATCHMENT AREA.

Oneida River, above mouth	1,401.6
Oneida River, above Brewerton	1,265.2

	Square miles.
Chittenango Creek, above mouth	308.7
Chittenango Creek, above gauging station	306.9
Oneida Creek, above mouth	148.6
Oneida Creek, above gauging station	59.0
Wood Creek, above mouth	126.5
Fish Creek, above Wood Creek	406.4
Fish Creek, East Branch, above gauging station	104.3
Fish Creek, West Branch, above gauging station	186.7

CATCHMENT AREAS OF STREAMS TRIBUTARY TO FEEDER LINE, ETC.

Deer Lick Creek	7.1
Side Hill	1.7
Townsend Brook	7.3
Rutland Hollow, east	0.1
Rutland Hollow, west	6.6
West Branch Sandy Creek	13.4
Rutland Creek	13.7
North Branch Sandy Creek	61.5
Rodman Brook	9.1
Adams Brook	8.7
Side Hill	1.0
South Branch Sandy Creek	44.3
Deer Creek	22.8
Lorraine Creek	8.8
Bear Creek	6.0
Pierpont Manor Creek	0.8
North Branch Skinner Creek	2.3
Middle Branch Skinner Creek	5.6
South Branch Skinner Creek	3.2
Lindsey Creek	4.0
North Branch Little Sandy Creek	3.2
Middle Branch Little Sandy Creek	2.3
Little Sandy Creek	13.3
Side Hill	2.0
Trout Brook	8.1
Side Hill	1.0
South Branch Trout Brook	9.4
Orwell Brook	8.0
Pekin Brook	6.2
Salmon River, above High Falls, at site of proposed reservoir dam (gauging station)	190.5
Salmon River, between gauging station and feeder line	8.4
Beaver Dam Brook	15.4
Fish Creek (West Branch), at Williamstown upper dam	16.2
Fish Creek (West Branch), at Williamstown lower dam	16.5
Fish Creek (West Branch), at West Camden	47.5
Fish Creek (West Branch), at De Lapp's dam	60.8
Fish Creek (West Branch), at Camden gristmill dam	61.4
Fish Creek (West Branch), at Camden foundry dam	61.5
Fish Creek (West Branch), at Planing Mill dam	61.5
Mad River, at mouth	52.1
Mad River, at Owens dam	46.6
Mad River, at Conants dam	46.5

	Square miles.
Little River	53.6
Corey Brook	9.1
Buell Brook	5.7
Beaver Brook, above feeder line	11.4
Canada Creek, above feeder line	34.0
Wood Creek, above Fort Bull	34.8

RUN-OFF DATA OF STREAMS IN STATE OF NEW YORK.

In the author's opinion the data for estimating water supplies of canals, especially when, as in the present case, they are on very large scale, should be based, when the data are available, upon actual gaugings of streams rather than on general considerations derived from study of rainfall. An examination of a large number of estimates of canal water supplies, based on the usual methods, shows that rainfall data alone are, in close cases, inadequate for solving a water-supply problem of the magnitude of the one now under consideration. When, however, actual gaugings of streams extending over sufficient number of years are available, there is no reason why a water-supply problem on a large scale may not be worked out with the precision of a proposition in mathematics. It is believed that in the present case the data are available for computing the water supply of the proposed deep waterways summit levels substantially with such precision. It is not intended to say, however, that rainfall data are not of use in a hydrologic discussion. When, as in the present case, in addition to stream gaugings, an extended series of such data are available, the argument is made doubly good and the demonstration strengthened. The discussion under this head will be extended in the chapter on Meteorology of New York and the Relations of Precipitation to Run-off. Plate 98 shows stations at which rainfall observations have been kept in the State of New York at places in or near the vicinity of catchment areas of Hudson, Mohawk, Black, Oswego, and Seneca rivers and Oneida Lake. The figures underneath the name of each station give the average rainfall in inches, the number of years of observation, and the elevation of the station above tide water. The detail of the precipitation records used in compiling plate 98 may be mostly found in Tables Nos. 20 to 118, accompanying this report.

In the State of New York fairly reliable gaugings of Croton River are available from the year 1870 to 1898, inclusive. This stream was gauged for a few years prior to 1870, but the record previous to that year is possibly open to some question, and is not generally used by hydrologists. Gaugings have also been made of Hudson River at Mechanicville from October, 1887, to the present time, and of Oatka Creek, a tributary of Genesee River, from April, 1890, to December, 1892, and of Genesee River at Rochester from March, 1893, to the present time, and also of the same stream at Mount Morris from September, 1893, to March, 1897. By making the proper reductions and compiling these several gaugings of Oatka Creek and Genesee River a useful record of Genesee River run-off from April, 1890, to the present time may be had, certain months omitted in the record being, however, obtained by interpolation. It is proper to observe, however, that the record for the years 1897 and 1898, which is based upon gaugings at Rochester, is somewhat approximative. It may be affected by errors of from 10 to 15 per cent. The balance of Genesee River record is considered to be much more accurate than this.

Without going into the subject extensively it may be remarked that the two important records for use in the present connection are those for Genesee and Hudson rivers, which have, accordingly, been compiled for the years 1892 to 1898, inclusive, and are herewith presented.[1]

Table No. 1 gives the run-off of Genesee River at Mount Morris, where the drainage area is 1,070 square miles, for the water years 1892-1898, inclusive, in inches on the watershed. Table No. 2 gives the same data in cubic feet per second, and Table No. 3 presents these data in cubic feet per square mile per second. These tables, as well as those following, are arranged for a water year beginning with the month of December of the previous year. Thus the water year 1892 begins with December, 1891, and so on throughout all the run-off and precipitation tables.

The following streams, tributary to proposed Black River feeder, are considered to have run-offs fairly comparable with that of Genesee River, namely: Deer Lick Creek, Townsend Brook, Rutland Hollow Creek, Sandy Creek, Rutland Creek, North Branch Sandy Creek, Rodman Brook, Adams Brook, South Branch Sandy Creek, Deer Creek, Lorraine Creek, Bear Creek, Pierrepont Manor Creek, North Branch Skinner Creek, Middle Branch Skinner Creek, South Branch Skinner Creek, North Bolyston Creek, North Branch Little Sandy Creek, Middle Branch Little Sandy Creek, and Little Sandy Creek. The catchment area of these streams, with intervening stretches of side hill area, is, roundly, 253 square miles. When examined on August 16–18, 1898, these streams were all nearly dry, the entire flow not exceeding 20 cubic feet per second. The catchment areas from which they issue are in the elevated region to the south of Watertown, which is mostly deforested and in a high state of cultivation, either for dairy or grain farming, and where the prevailing rocks are limestone and shales, with heavy, impervious soils. As shown in the chapter on Flood Flows of Streams in the State of New York, the flood discharges of many of these streams are very heavy, while from the impervious nature of the soil and its small capacity for retaining water, the summer flows are either very light or practically nothing. Such characteristics at once place these streams in same category as Genesee River.

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[1] Complete details of Hudson and Genesee rivers run-off records may be found in Water-Supply and Irrigation Papers of the United States Geological Survey, Nos. 24 and 25—"Water resources of the State of New York," by George W. Rafter. Also in the original reports on Genesee and Hudson Rivers Storage Projects in the annual reports of the State engineer and surveyor of the State of New York. Discussions of various phases of these records may be found in the author's paper on the "Data of stream flow in relation to forests," a lecture before the engineering classes of Cornell University, April 14, 1899, to be found in the Proceedings of the Association of Civil Engineers of Cornell University, 1899.

Table No. 4 has been computed from the Genesee River data as per table No. 3, and gives the run-offs of the foregoing streams tributary to the feeder line for the navigation months of each year from 1892 to 1898, inclusive, the month of April being taken in the first part of the table as one-half a month. This gives a period from April 15 to November 30, inclusive, of 229 days, or 7 days more than the average season of navigation on Erie Canal, the extra time of water supply being required, however, in order to cover possible contingencies of filling.

In case of demands for water before April 15 the records show the run-off of tributary streams as sufficient; or, if there were to be a slight shortage, it could be met either by draft on the excess storage of Black River reservoir or from the emergency reservoirs of the Susquehanna-Mohawk divide.

The detail of Hudson River gaugings has been given so fully in the reports on Hudson River Storage, to be found in the annual reports of the State engineer and surveyor, and also in the author's reports on Water Resources of the State of New York, Water-Supply and Irrigation Papers of the United States Geological Survey, Nos. 24 and 25, as to render extended description unnecessary in this place. Table No. 120 also embodies these data.

Table No. 5 gives the run-off of Hudson River at Mechanicville, where the catchment area is 4,500 square miles, in inches on the area, for the water years 1892 to 1898, inclusive. In regard to the catchment area of Hudson River at Mechanicville, a computation thereof made from catchment area map, plate 94, indicates 4,506.7 square miles as the true figure, rather than 4,500 square miles, the figure previously obtained from less accurate maps. This difference is, however, so small that it has been deemed best not to recompute the vast amount of accumulated data of the author's work in previous years, which hinge upon an assumed catchment area at Mechanicville of 4,500 square miles, and that figure has accordingly been retained for the computations in this report. In any case, the error is only about fifteen-hundredths of 1 per cent.

Table No. 6 gives the same data of Hudson River as table No. 5, with the run-offs in cubic feet per second.

Table No. 7 gives the run-off of Hudson River for the water years 1892 to 1898, inclusive, in cubic feet per square mile per second.

In table No. 8 we have the run-off of streams tributary to the proposed Black River feeder and which are considered to be in the same category as Hudson River, namely: Trout Brook, South Branch of

Trout Brook, Orwell Brook, Pekin Brook, Salmon River, Beaver Dam Brook, West Branch of Fish Creek, Mad River, Little River, Corey Brook, Buell Brook, and East Branch of Fish Creek, the total catchment area of these streams, with small intervening areas, being 443 square miles, which, however, does not include Salmon River area of 190.5 square miles above proposed barrage on that stream.

In passing from north to south along feeder line the character of the country changes at about Trout Brook. The difference in flow of streams here was exceedingly marked when the author passed over the ground on reconnoissance, August 18, 1898. To the north of Trout Brook the streams were, as stated on a previous page, dry or nearly dry. That stream, however, had a good discharge, as did Pekin and Orwell brooks, Salmon River, and Beaver Dam Brook. So far as known, the meteorological conditions of the two regions had remained constant for several days previously. The difference in run-off may be partly ascribed to difference in forestation, the areas from which Trout and Pekin brooks, Salmon River, and Beaver Dam Brook issue being much more extensively timbered than the areas farther north. The surface soils are also open and sandy, with the underlying rock consisting largely of Oswego sandstone—conditions which all tend to increase the summer water yield of the issuing streams. Taking into account also the meteorology of the region, it appears proper to apply to these streams the run-off data of Hudson River, and it is on this basis that table No. 8 has been computed, the first period covered being taken, as in the case of table No. 4, from April 15 to November 30, inclusive.

In Oswego–Mohawk valleys there are a number of streams of which the run-offs are not properly classifiable either with Genesee River or with Hudson. A study of the gaugings of these streams made from September, 1898, to May, 1899, inclusive, together with a study of the topographical, geological, and forestry conditions, indicate that these streams fall in a category by themselves, apparently best represented by a run-off which is a mean between Genesee and Hudson rivers data. Table No. 9 has been prepared on this basis for the water years 1892–1898, inclusive.

Table No. 10 shows the run-off from Upper Mohawk and Nine-Mile Creek, with a total catchment area of 226.1 square miles, for the water years 1892–1898, inclusive, based on means of Genesee and Hudson rivers data, as per table No. 9, with quantities in cubic feet per second.

There are also a number of streams in the vicinity of Rome and Utica of which the run-off coefficient is somewhat uncertain, the information at hand indicating, however, Genesee River more nearly than anything else. As a measure of safety it has been deemed best to apply Genessee River data to the following streams: Six Mile Creek, Beaver Brook, Canada Creek, Wood Creek above Fort Bull, Sauquoit Creek, and Oriskany Creek. The total catchment area of these streams is 348 square miles. Table No. 11 gives the mean monthly run-offs in cubic feet per second for the water years 1892–1898, inclusive, on the basis of Genesee River data. Table No. 12 gives evaporation from a water surface, as observed at Mount Hope reservoir of Rochester waterworks from 1892 to 1898, inclusive. The application of these several tables to the solution of the water-supply problem in hand will appear as we proceed further with the discussion.

TABLE NO. 1—*Showing run-off of Genesee River at Mount Morris, N. Y.*

[In inches on the catchment area.]

Month.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
December	1.04	1.45	2.34	0.61	1.32	0.79	0.95
January	.78	1.95	1.40	.66	.47	.78	1.95
February	1.66	1.29	.86	.22	.91	.79	1.85
March	1.94	2.31	3.31	1.94	3	2.65	2.75
April	2.21	2.50	3.39	2.01	3.38	1.31	1.65
May	1.75	2.60	4.43	.19	.17	.99	1.25
June	1.41	.35	1.10	.13	.39	.44	.80
July	2.06	.30	.14	.11	.24	.46	.45
August	1.43	.35	.22	.12	.20	.44	.80
September	.24	.33	.93	.10	.16	.18	.50
October	.33	.38	.44	.11	1.74	.18	.78
November	.57	.54	.82	.47	.82	.37	1.40
Totals	15.42	14.35	19.38	6.67	12.80	9.38	15.33

TABLE NO. 2.—*Showing mean run-off of Genesee River at Mount Morris, N. Y., from a catchment area of 1,070 square miles.*

[In cubic feet per second.]

Month.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
December	965	1,346	2,170	568	1,226	733	882
January	724	1,810	1,297	604	436	724	1,810
February	1,624	1,325	884	224	907	812	1,900
March	1,803	2,144	3,074	1,803	2,786	2,459	2,552
April	2,119	2,397	3,245	1,927	3,245	1,256	1,582
May	1,624	2,413	4,108	174	157	919	1,160
June	1,352	336	1,050	128	374	422	767
July	1,912	278	132	105	226	427	418
August	1,327	325	200	115	188	408	742
September	230	316	888	100	148	173	464
October	306	373	407	104	1,664	167	724
November	547	518	782	449	782	355	1,342
Means	1,211	1,132	1,525	526	1,005	738	1,195

TABLE NO. 3.—*Showing the mean run-off of Genesee River at Mount Morris, N. Y., for each square mile of catchment area.*

[In cubic feet per second.]

Month.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
December	0.902	1.259	2.028	0.530	1.145	0.685	0.824
January	.676	1.699	1.212	.564	.407	.676	1.691
February	1.517	1.238	.826	.209	.847	.759	1.775
March	1.682	2.004	2.873	1.685	2.604	2.295	2.385
April	1.980	2.239	3.033	1.800	3.033	1.174	1.474
May	1.518	2.255	3.839	.163	.147	.858	1.084
June	1.263	.314	.981	.119	.349	.394	.717
July	1.787	.259	.123	.098	.211	.400	.391
August	1.146	.304	.187	.107	.176	.381	.693
September	.214	.295	.830	.093	.138	.161	.430
October	.276	.348	.380	.097	1.555	.156	.677
November	.511	.484	.731	.419	.824	.331	1.754
Means	1.123	1.058	1.420	.490	.953	.690	1.133

Table No. 4.—*Showing run-off of streams tributary to Black River feeder, north of Trout Brook, based on Genesee River data for years 1892–1898, inclusive.*

[Catchment area of 253.3 square miles. Quantities in cubic feet per second.]

Period.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
April	502	567	767	456	768	297	373
May	385	571	972	41	37	218	205
June	320	80	248	30	88	100	182
July	453	66	31	25	52	101	99
August	290	77	47	27	45	97	176
September	54	75	210	24	35	41	109
October	70	88	96	25	394	40	171
November	129	123	185	106	209	84	444
Means	264	182	290	67	166	111	217
December (preceding year)	228	319	514	134	565	174	209
January	171	430	307	143	103	173	428
February	384	314	209	53	215	192	450
March	426	508	728	427	660	581	603
April	502	567	767	456	768	297	373

Table No. 5.—*Showing run-off of Hudson River at Mechanicville, N. Y.*

[In inches on the catchment area.]

Month.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
December	2.27	1.03	1.85	1.12	2.79	1.77	3.67
January	4.83	.82	1.73	.99	1.74	1.03	1.97
February	2.22	1.00	1.12	.82	1.12	.90	1.56
March	2.80	2.11	3.78	1.08	3.49	3.13	5.18
April	5.35	4.44	2.76	5.91	6.20	4.73	3.40
May	5.03	5.71	1.94	1.76	1.18	3.04	2.83
June	3.08	1.19	1.76	.70	1.18	2.94	1.30
July	2.38	.65	.81	.66	.72	2.74	.64
August	1.41	1.28	.63	1.00	.63	2.11	1.30
September	1.10	1.70	.47	.65	.71	.68	.98
October	.72	.99	.94	.69	1.05	.65	2.02
November	1.89	.90	1.58	2.08	2.82	2.47	2.29
Totals	33.08	21.90	19.37	17.46	23.63	26.19	27.12

Table No. 6.—*Showing mean run-off of Hudson River at Mechanicville, N. Y., from a catchment area of 4,500 square miles.*

[In cubic feet per second.]

Month.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
December	8,577	4.031	7,217	4,367	10,889	6,913	13,741
January	18,857	3,192	6,737	3,876	6,787	4,007	7,723
February	9,263	4.805	4,836	3,543	4,668	3,895	6,754
March	10,929	8,250	14,738	4,204	13,600	11,214	20,220
April	21,554	17,880	11,135	23,822	24,972	19,080	13,712
May	19,622	22,285	7,566	6,850	4,610	12,151	11,035
June	12,395	4,801	7,097	2,816	4,738	11,861	5,240
July	9,287	2,521	3,168	2,559	2,772	10,722	2,570
August	5,485	5.005	2,456	3,901	2,442	8,240	5,191
September	4.448	6,870	1,889	2,629	2,879	2,756	3,872
October	2.819	3.865	3,649	2,631	4,106	2,524	7,895
November	7.604	3,639	6,379	8,421	11,352	9,902	9,243
Means	10,909	7,271	6.418	5,780	7,818	8,694	8,934

Table No. 7.—*Showing mean run-off of Hudson River at Mechanicville, N. Y., for each square mile of catchment area.*

[In cubic feet per second.]

Month.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
December	1.906	0.896	1.604	.970	2.420	1.536	3.053
January	4.190	0.709	1.501	.861	1.508	.890	1.716
February	2.058	1.068	1.075	.787	1.037	.865	1.501
March	2.428	1.833	3.275	.934	3.022	2.492	4.493
April	4.790	3.975	2.468	5.310	5.550	4.240	3.070
May	4.360	4.953	1.681	1.522	1.024	2.700	2.466
June	2.755	1.067	1.577	.628	1.053	2.636	1.173
July	2.638	.560	.704	.502	.616	2.394	.571
August	1.219	1.112	.546	.867	.543	1.831	1.133
September	.988	1.527	.411	.584	.514	.512	.838
October	.626	.859	.811	.584	.912	.561	1.754
November	1.690	.809	1.415	1.871	2.967	2.214	2.054

Table No. 8.—*Showing run-off of streams tributary to Black River feeder, including Trout Brook and streams south thereof, based on upper Hudson data for years 1892–1898, inclusive.*

[Catchment area of 443 square miles. Quantities in cubic feet per second.]

Period.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
April	2,123	1,720	1,092	2,353	2,460	1,880	1,360
May	1,931	2,194	745	674	454	1,196	1,092
June	1,220	473	684	277	466	1,168	520
July	1,168	248	312	222	273	1,061	253
August	540	493	243	384	241	811	501
September	438	676	182	259	228	227	371
October	277	381	359	259	417	248	777
November	749	358	627	829	1,314	981	908
Means	1,089	759	496	541	614	874	681
December (preceding year)	844	398	710	430	1,072	680	1,352
January	1,856	314	665	381	688	394	760
February	912	473	476	349	459	383	665
March	1,075	812	1,451	414	1,339	1,104	1,990
April	2,120	1,720	1,092	2,352	2,460	1,880	1,360

Table No. 9.—*Showing the mean run-off between Genesee and Hudson rivers data.*

[In cubic feet per second per square mile.]

Month.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
December	1.404	1.077	1.816	0.750	1.783	1.110	1.838
January	2.428	1.204	1.356	.713	.957	.783	1.067
February	1.787	1.153	.950	.498	.942	.812	1.238
March	2.055	1.918	3.074	1.309	2.813	2.394	3.439
April	3.385	3.157	2.750	3.555	4.291	2.707	2.272
May	2.930	3.604	2.760	.842	.585	1.779	1.775
June	2.009	.690	1.279	.372	.701	1.515	.945
July	2.212	.400	.413	.300	.413	1.397	.481
August	1.182	.708	.366	.487	.359	1.106	.913
September	.601	.911	.620	.338	.326	.336	.634
October	.481	.603	.645	.340	1.233	.358	1.215
November	1.101	.646	1.073	1.145	1.895	1.272	1.904

Table No. 10.—*Showing run-off from Upper Mohawk River and Nine Mile Creek, for years 1892 to 1898, inclusive, based on mean of Genesee and Hudson rivers data. Total catchment area = 226.1 square miles.*

[In cubic feet per second.]

Month.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
December	317	244	411	170	403	251	415
January	549	272	307	161	216	177	377
February	404	261	215	113	213	184	280
March	465	434	685	296	636	541	779
April	765	714	622	804	970	612	513
May	665	815	624	190	132	402	401
June	454	156	289	84	158	343	214
July	500	92	93	68	93	316	103
August	287	160	83	110	81	650	296
September	134	206	140	76	73	76	143
October	102	136	146	77	279	80	275
November	249	146	243	259	428	287	430

Table No. 11.—*Showing run-off from Six Mile Creek, Beaver Brook, Canada Creek, Wood Creek (above Fort Bull), and Sauquoit and Oriskany creeks, having a total catchment area of 348 square miles. Based on Genesee River data for years 1892 to 1898, inclusive.*

[In cubic feet per second.]

Month.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
December	314	438	706	184	398	238	287
January	235	591	422	196	142	235	589
February	528	431	287	73	295	264	618
March	585	697	1,000	586	906	799	830
April	689	779	1,055	626	1,055	409	513
May	528	785	1,834	57	51	299	377
June	440	109	341	41	121	137	250
July	622	90	43	34	73	139	138
August	399	106	65	37	61	133	241
September	75	103	289	32	48	56	150
October	96	121	132	34	541	54	236
November	178	169	254	146	287	115	610

Table No. 12.—*Evaporation from a water surface as observed at Mount Hope Reservoir of Rochester (N. Y.) Waterworks, for the indicated months and years.*

[In inches.]

Month. (1)	1892. (2)	1893. (3)	1894. (4)	1895. (5)	1896. (6)	1897. (7)	1898. (8)	Averages. Period. (9)	Averages. Depth. (10)
January					0.45	0.59	0.56	1896-1898	0.53
February					.45	.62	1.01	1896-1898	.69
March					.91	1.76	1.56	1896-1898	1.41
April	2.78	2.78	2.59	2.72	2.72	2.45	3.41	1894-1898	2.78
May	3.26	3.33	3.32	4.00	5.72	3.36	3.64	1892-1898	3.89
June	4.62	4.61	3.62	5.75	6.04	5.01	5.65	1892-1898	5.05
July	6.06	5.80	5.31	5.92	5.19	4.43	6.85	1891-1898	5.64
August	4.85	5.36	6.20	5.13	5.23	5.37	4.98	1891-1898	5.26
September	4.61	3.47	3.76	5.14	3.38	4.66	3.95	1891-1898	4.13
October	3.28	3.27	2.96	3.61	2.45	3.33	2.57	1891-1898	3.08
November				1.51	1.50	1.33	1.57	1895-1898	1.48
December				1.23	1.20	.96	1.54	1895-1898	1.23

GAUGING OF STREAMS TRIBUTARY TO DEEP WATERWAYS IN CENTRAL AND EASTERN NEW YORK.

At the beginning of the special water-supply investigation it was deemed advisable to gauge a considerable number of streams tributary to deep waterways in central and eastern New York, not only with reference to extending our information as to low-water flow of Oswego, Mohawk, and Hudson rivers, but especially to gain more definite knowledge of the flood flows of these streams and their tributaries, it being clearly recognized that the control of floods in the canalized river beds was a very serious feature of the general problem. Acting on this view, 20 gauging stations were established, as shown by Nos. 1 to 20, inclusive, on plate 99, which also indicates catchment areas tributary to deep waterways and from which it is necessary to consider run-offs in the special water-supply investigation. In addition to the 20 stations established in connection with the present work there are also shown, on plate 99, 3 stations previously established by the author in connection with work for the State of New York. Finally, a station had been established by the Watertown Waterworks on Black River at Huntingtonville, a suburb of the city of Watertown, and of which the data have been kindly placed at our disposal by the board of water commissioners of the city of Watertown from the beginning of observations in March, 1897, down to date. The gauging station on Hudson River at Mechanicville is that previously referred to and at which point records have been kept by The Duncan Company from October, 1887, to the present time.

The following are the serial numbers and names of these several gauging stations:

1. **Seneca River at Baldwinsville.**
2. **Oswego River at Fulton.**
3. **Chittenango Creek at Bridgeport.**
4. **Oneida Creek at Kenwood.**
5. **Wood Creek, near mouth.**
6. **Fish Creek, west branch, at McConnellville.**
7. **Fish Creek, east branch, above Point Rock.**
8. **Salmon River, about 1 mile above falls.**
9. **Mohawk River at Ridge Mills.**
10. **Nine Mile Creek, 1 mile below Stittville.**
11. **Oriskany Creek, State dam, Oriskany.**
12. **Oriskany Creek at Coleman.**
13. **Sauquoit Creek at New York Mills.**
14. **West Canada Creek at Middleville.**
15. **Mohawk River at Little Falls.**
16. **East Canada Creek at Dolgeville.**
17. **Garoga Creek, 3 miles above mouth.**
18. **Cayadutta Creek, below Johnstown.**
19. **Schoharie Creek, State dam, Fort Hunter.**
20. **Mohawk River at Rexford Flats.**
21. **Hudson River at Mechanicville.**
22. **Hudson River at Fort Edward.**
23. **Schroon River at Warrensburg.**
24. **Black River at Huntingtonville.**

With the exception of Hudson River at Fort Edward, the catchment areas of these several streams at the points of gauging may be obtained from the tabulation of catchment areas on pages 921 to 924.

In regard to Hudson River at Fort Edward and Schroon River at Warrensburg, it may be stated that while the run-off data at these places are available, no specific use for them appearing in the present work, it has not been considered worth while to expend the considerable amount of labor necessary for their reduction. The record of these gaugings at Fort Edward and Warrensburg, as well as at Mechanicville, together with the Black River record at Huntingtonville, have all been furnished without expense to your Board. The Genesee River record at Rochester from December, 1897, to May, 1899, inclusive, has also been furnished without expense by E. A. Fisher, city engineer of Rochester. The author takes this occasion to express his thanks to the parties keeping these several records for kindly furnishing them.

Diagrams showing the daily flow of Hudson River at Mechanicville from October, 1887, to November, 1895, may be found in the annual report of the State engineer and surveyor of the State of New York for the fiscal year ending September 30, 1895. Plate 100, accompanying this report, is a continuation of the said diagrams from December, 1895, to November, 1898, inclusive. The diagrams in the annual report of the State engineer and surveyor for 1895 (plates 1, 2, 3, and 4 of the author's report on the Upper Hudson storage surveys), together with plate 100 of this report, therefore make a continuous exhibit of the daily flow of Hudson River at Mechanicville from October, 1887, to November, 1898, inclusive, a period of eleven years and two months. On referring to plate 4 of the annual report of the State engineer and surveyor for 1895 and to plate 100 of this report, it will be observed that the tide record at Albany for the months of navigation in Hudson River has been plotted thereon covering the years from 1894 to 1898, inclusive. The significance of this tide diagram in connection with the daily run-off of Hudson River has been discussed in the author's report to the State engineer and surveyor on the Upper Hudson storage surveys for 1895 so extensively as to render additional discussion unnecessary here any further than to point out that the demonstration of intimate relation existing between tide fluctuations and daily inflow of fresh water is considerably strengthened by the additional three years' record presented on plate 100.

Plate 101 gives the daily flow of Black River at Huntingtonville from February, 1897, to May, 1899, inclusive, together with the precipitation and mean temperature. The full line on the diagram of daily flow shows the actual run-offs at Huntingtonville as gauged at the dam of the waterworks of the city of Watertown, while the daily flow of the stream, as computed from proportionality of catchment areas from data of Hudson River at Mechanicville, is shown by the dotted line. A comparison of the two shows that the run-offs of Hudson and Black rivers per unit of catchment area are, for a considerable period, substantially the same. At one period the actual observed run-off at Huntingtonville is higher than the computed run-off from Hudson data, while at other times the opposite is true. A comparison of the monthly means of the two, as made on plate 102, brings out very strongly the substantial accord per unit area of these two streams. On plate 102, however, instead of comparing daily run-offs in cubic feet per second, the monthly run-offs in inches on the catchment areas are compared.

Tables Nos. 122 and 123 give the same comparison for these two areas. From them we learn that the total difference for the water year 1898 is 1.68 inches. In reference to this difference it may be remarked that it is probably chiefly due to different methods of computation, the author's opinion being that, on account of similarity of meteorological, topographical, and geological conditions, the run-offs of these two streams are for any given period substantially the same; and while it is recognized that even though this is, on the whole, true, still there might be small variations for periods of one or two years. Nevertheless, it is probable that the variation is, as stated, due chiefly to difference in methods of computation.

Under this head it may be remarked that when the run-off of Hudson River at Mechanicville was computed in 1895, practically the only formula in use in the United States for such computation was the sharp-edged weir formula of Mr. Francis, and although there were a few engineers who had studied flows over dams, and who were aware that a formula based on sharp-edged weir experiments was not applicable to a nearly flat-crested dam, such as that at Mechanicville, nevertheless no one had been able to work out any substitute which had gained general acceptance. In making this statement the author does not overlook the valuable experiments of Messrs. Fteley and Stearns or the able theoretical deductions of J. P. Frizell. The broad statement is that in 1895 American engineers were practically confined to the use of Mr. Francis's sharp-edged weir formula for flows over dams, whatever the depth of flow might be and whatever the profile of the crest. Recognizing in some degree the irrationality of this procedure, the author, after considerable study of the problem, used for the computation of the Mechanicville data the formula of the Indian engineers, as given by Lieutenant-General Mullins in his Irrigation Manual. Inasmuch as this formula is given at length in his report to the State engineer and surveyor in 1895, and also in Water-Supply and Irrigation Paper of the United States Geological Survey, No. 24—Water Resources of the State of New York, Part 1—the author will not take space to reproduce it here, but simply refer those interested to the reports cited, where it may be found, or to Mullins's Irrigation Manual for its original form. The Black River data have been reduced by an application of the coefficients of Bazin, modified by the Cornell University experiments, to be discussed further on. As the result of the special studies herewith included, it is the author's belief that the computation of daily run-off from the Black River data, while still a little too high, is nevertheless more accurate than the computation of Hudson run-off from the East Indian formula. It is certain, however, that the East Indian formula was a great improvement over the use of any sharp-edged weir formula on a flat-crested dam whatever. Taking into account, therefore, that Black River run-off as computed is a little high and Hudson River a little low, we may assume the two as substantially equal.

It being conceded, then, that the comparison of run-offs of Hudson and Black rivers, as made on plates 101 and 102, shows that for the period actually covered (March, 1897, to May, 1899, inclusive) the run-offs of these two streams were the same for a period as long as two years and two months, they may be expected to fairly agree for any period whatever. Hence, having the run-off record of one stream, together with the catchment areas of both, we may compute for a series of years the approximate run-off of the other stream. Proceeding on this basis, plates 103, 104, and 105 have been prepared, giving a diagram of daily run-off of Black River for the entire period covered by the Hudson River Mechanicville record, except so far as we have a record of Black River itself on plate 101. That is to say, plates 103, 104, and 105 cover the period from October, 1887, to January, 1897, inclusive, the balance of Black River record being shown on plate 101, as previously described. Plates 101, 103, 104, and 105 give, therefore, a complete diagram of daily run-off of Black River from October, 1887, to May, 1899, inclusive. These diagrams enable one to estimate the effect upon Black River of the proposed storage and compensation reservoir above Carthage.

Before proceeding to a description of each gauging station in detail, we will describe the general methods pursued in these gaugings. In the first place, with the exception of Wood Creek, the gaugings have all been made over existing dams on the several streams. Many of these dams have irregular crests, both longitudinally and transversely, and the method of treatment, in order to obtain correct results, frequently became a matter of some difficulty. In a few cases, as on Nine Mile Creek, West Canada Creek, etc., where the crests were very irregular longitudinally, a small amount of work was done in the way of leveling the same. Generally, however, the crests were left in the same condition as found, a careful profile taken, and the crest divided into a series of approximately level sections, as will be described more in detail in another place. A gauging blank was also furnished the gauge readers with columns for entering depth on crest of dam forenoon and afternoon, the number of wheels used, size of same, name of manufacturer and daily run, working head on wheels, readings of headrace and tailrace gauges, and other information necessary for keeping an accurate account of the water actually passing over the crest for twenty-four hours, as well as through the water wheels for the same period. Gauge readers were employed to make these readings twice each day. In order to obtain the flows through the water wheels, recourse was had to the records of the test flume of the Holyoke Water Power Company, of Holyoke, Mass., where the principal wheels now in common use in the State of New York have at one time and another been tested. On requesting a record of such tests as applying to wheels at the several gauging stations Nos. 1 to 20, the Holyoke Water Power Company kindly responded that they would furnish the records under the condition that they be not published except the consent of the parties for whom the wheels had been tested was first obtained. This condition being assented to, information was furnished as to tests of the principal wheels in use, giving the proportional part of the opening of the speed gate for various conditions of tests, revolutions of the wheel, quantity of water discharged, power developed, and efficiency, etc. From these records discharge curves have been prepared, of the form shown on plate 106, which embodies the data of a 36-inch new American turbine wheel, as furnished for publication by the manufacturers, the Globe Iron Works Company, of Dayton, Ohio, and which is not subject to the inhibition of nonpublication made by the Holyoke Water Power Company of the unpublished tests furnished from their records. By the use of such series of curves derived from actual tests, it is believed that the discharges through the turbine water wheels at the various gauging stations have been computed with a very high degree of accuracy. In a few cases, where there were no tests applying, the discharges as per manufacturers' tables have been used. The author's thanks are due Holyoke Water Power Company for the courtesy of furnishing these useful data.

The locations, details, etc., of the dams at the several gauging stations, Nos. 1 to 20, inclusive, may be obtained from plate 107 to plate 126, inclusive, on which are given, in addition to general plans of the dams, longitudinal sections, profiles, etc., together with the discharge curve at each station as computed by the methods to be described in detail in the chapter on methods of computing discharge over dams at the several gauging stations. The following brief notes on the several gauging stations are given herewith for convenient reference.

Gauging station No. 1 (plate 107) is located on Seneca River, a tributary to Oswego at Baldwinsville, where the catchment area above the point of gauging is 3,103 square miles. The dam is a substantial masonry structure with cross section, as shown on plate 107, and built in 1894–95, taking the place of an old crib dam located just above the new dam, and also shown in section on plate 107. The dam is the property of the State of New York, being a part of the State canal system.

Water is taken from the dam by two mill raceways and also by the Baldwinsville side-cut canal and delivered to 10 manufacturing establishments, where, after passing through turbine water wheels, a large percentage of the flow is returned to the river below the dam. The following are the names of the manufacturing establishments which have allowed daily records of wheel service to be kept: Kenyon Paper Company, Hotaling & Co., Clark & Mercer, J. & J. C. Miller Company, Jacob Ames, Morris Machine Company, J. Frazee Milling Company, C. E. Hart, C. N. Bliss, and Penn Spring Works. The length of the crest of Baldwinsville dam is 423 feet.

According to statements of parties at Baldwinsville, the new dam is nearly water-tight. There is, however, considerable leakage at a number of flumes and bulkheads which, together with a small amount of wastage, has been taken as constant at 100 cubic feet per second, which quantity has been added to the computed flow over the dam and through the water wheels.

Gauging station No. 2 (plate 108) is located on Oswego River at Fulton, where the catchment area above the point of guaging is 4,915.6 square miles. The dam at this station is, the same as at Baldwinsville, the property of the State of New York, forming a part of Oswego Canal slack-water navigation. The Oswego Falls Pulp and Paper Company occupy the east side of the river with their pulp and paper mill, while the west side is occupied by the extensive worsted mills of The American Woolen Company. Plate 108 shows a general plan of the locality, as well as a profile of the crest of spillway and section of dam.

This dam is considered to be so nearly water-tight that leakage may be neglected.

Gauging station No. 3 (plate 109) is located on Chittenango Creek, a tributary to Oneida Lake at Bridgeport, where the catchment area above the point of gauging is 306.9 square miles. The developed water-power at Bridgeport consists of a gristmill on the east side of the stream and a sawmill on the west side, both owned by Snyder Brothers. Details of the location, profiles, sections, etc., are shown on plate 109.

The dam itself is fairly water-tight, but there is a race diverting water to an old mill, mostly out of service, which has a leaky flume. The leakage through the flume and bulkhead of this mill and through the dam has been taken, as a matter of judgment, at 15 cubic feet per second.

Gauging station No. 4 (plate 110) is located on Oneida Creek, a tributary to Oneida Lake at Kenwood, where the catchment area above the point of gauging is 59 square miles. The dam is the property of the Oneida Community Company, the developed water power consisting of a silk mill. The details of the location, profile, sections, etc., are shown on plate 110.

The leakage of this dam has been taken constant at 5 cubic feet per second and of flow over waste ways at 10 cubic feet per second. This latter figure is approximately right for ordinary flows, but probably somewhat small for flood flows.

Gauging station No. 5 was established on Wood Creek, near its mouth, as a current-meter rating station. Proper locations on this stream were difficult to find, and after some hesitation a reach near Fish Creek village was decided upon as the best available, and the station rated by current-meter observations taken at several different stages of flow. Unfortunately, it turned out that the flood run-offs of Fish Creek, even with comparatively small rise, flowed over into Wood Creek, vitiating the record. With this state of facts it has not been deemed worth while to work up the Wood Creek results, and they are accordingly omitted from the accompanying tabulations of gaugings.

Gauging station No. 6 (plate 111) is located on West Branch of Fish Creek, a tributary to Oneida Lake, at McConnellsville, where the catchment area above the point of gauging is 186.7 square miles. The dam is the property of Charles and Frank S. Harden, who operate a sawmill on the south side and a chair factory on the north side. The crest was originally quite irregular longitudinally, but was brought up to a uniform level at slight expense. A plan, profile, and cross section of the dam are given on plate 111.

The leakage of this dam has been taken constant at 10 cubic feet per second.

Gauging station No. 7 (plate 112) is located on East Branch of Fish Creek, also a tributary to Oneida Lake, at Point Rock, where the catchment area above the point of gauging is 104.3 square miles. The only power in use at this place is at sawmill on the south side, owned by Fowler W. Willson, which, however, has not been in use except for an occasional day during the period covered by the gaugings. The record of flow at this station is, therefore, that chiefly due to discharge over dam. The usual detailed information is given on plate 112.

The leakage has been taken constant at 10 cubic feet per second.

Gauging station No. 8 (plate 113) is located on Salmon River, 1 mile above the high falls, in the town of Orwell, where the catchment area above the point of gauging is 190.5 square miles. The dam is owned by Post & Henderson, who formerly operated a sawmill, which, however, is not now in use. The dam was found to leak badly, and in order to determine the amount of the same a current meter determination of the total flow was made at Stillwater bridge, where a favorable section for current meter work was found, the difference between the flow at that point and the flow over the dam being 88 cubic feet per second, which quantity has accordingly been added to the daily flows as determined from the gauging record. The current meter used for this purpose was a small Price meter, loaned by the United States Geological Survey. The usual plans, profiles, and section are given on plate 113.

Gauging station No. 9 (plate 114) is located at Ridge Mills, on Upper Mohawk River, a short distance above Rome, where the catchment area above the point of gauging is 152.5 square miles. The dam on which the gaugings were made is the property of the city of Rome, the developed water power being used to produce power for the pumping station of the Rome waterworks. A general plan, profile of crest, and cross section of dam are shown on plate 114.

This dam is substantially built and is practically water-tight, the leakage probably not exceeding 5 cubic feet per second.

Gauging station No. 10 (plate 115) is located on Nine Mile Creek, a tributary to Mohawk, near Stittville, where the catchment area above the point of gauging is 62.6 square miles. The dam on which the gaugings were made is the property of Raymer Powell, who operates a grist and saw mill. Very little work has been done at these mills during the gauging period, and the gauging record is, therefore, confined to the daily flow over the dam. Refer to plate 115 for details.

The leakage of this dam is also taken at 5 cubic feet per second.

Gauging station No. 11 (plate 116) is located on Oriskany Creek, a tributary to Mohawk, at Oriskany, where the catchment area above the point of gauging is 144.3 square miles. The dam is the property of the State of New York, its purpose being to divert water from Oriskany Creek to Erie Canal. During navigation months a record was kept of the gate openings, together with daily observations of difference of water surfaces above and below gates. Outside of navigation months the feeder gates are entirely closed and the record is that of flow over dam only. A plan, profile of crest, and cross section of dam may be seen on plate 116.

This dam is considered to be so nearly water-tight that leakage has been neglected.

Gauging station No. 12 (plate 117) is also located on Oriskany Creek, at Coleman, where the catchment area above the point of gauging is 140.7 square miles. The dam is the property of W. S. Reeder and others, the developed water power being used to operate a gristmill, sawmill, picking mill, etc. The details of the location, with profile of crest and section of dam, may be seen on plate 117.

The object of establishing two stations on Oriskany Creek was to determine whether on dams of somewhat different forms but with substantially the same catchment area the flows could be gauged close enough to give comparable figures. The methods of computation used are described in the chapter on methods of computing discharge over dams at the several gauging stations, and it is sufficient for present purposes to refer to the accompanying tabulation, in which we have given the flows at stations Nos. 11 and 12 for the months from October, 1898, to February, 1899, inclusive. During the winter months January to February the ice was kept clear from the crests of both dams. The results show close agreement and indicate that even when one of the cases is complicated by discharge through a number of water wheels, as at station No. 12, comparable results may still be gained. The following are the flows at the two stations for the months, stated in cubic feet per second. The apparent discrepancy at station No. 11 in October is explained by the fact that the figures for that month are the means of only the last sixteen days.

Month.	Station No. 11, Oriskany.	Station No. 12, Coleman.
October, 1898	325	246
November, 1896	327	306
December, 1898	327	335
January, 1899	295	297
February, 1899	291	283

. The leakage has been taken at 20 cubic feet per second.

Gauging station No. 13 (plate 118) is located on Sauquoit Creek, a tributary to Mohawk, at Upper New York Mills, where the catchment area above the point of gauging is 51.5 square miles. The dam is the property of the New York Mills, the water power being used to operate an extensive cotton mill. Plan, details, etc., may be seen on plate 118. This dam is water-tight and leakage neglected.

Gauging station No. 14 (plate 119) is located on West Canada Creek, a tributary to Mohawk, at Middleville, where the catchment area above the point of gauging is 518.7 square miles. The dam is owned by the Nelson Knitting Company and other manufacturing establishments, the water power being used to operate the large knitting mill of the Nelson Knitting Company, a gristmill, sawmill, and planing mill. For details see plate 119.

From observations made with the water drawn below the crest the leakage has been placed at 50 cubic feet per second. As shown on the map (plate 119) there is a waste way near the New York Central and Hudson River Railroad depot. A daily record of depths on this waste way has been kept and the proper quantity added to the daily flow.

Gauging station No. 15 (plate 120) is located on Mohawk River at Little Falls, where the catchment area above the point of gauging is 1,306 square miles. The dam is the property of the Astronga Knitting Mill Company and the Little Falls Paper Company, the developed water power being used to operate a knitting mill and a paper mill. Plans, profiles, and sections are shown on plate 120.

The dam is a substantial masonry structure, erected in 1897, and is water-tight.

Gauging station No. 16 (plate 121) is located on East Canada Creek, a tributary to Mohawk at Dolgeville, where the catchment area above the point of gauging is 255.6 square miles. The dam is a substantial masonry construction and is the property of the Dolgeville Electric

Power Company, the developed water power being used to operate an electric-power station, from which electric light and power are supplied to the village of Dolgeville. The plans and sections are given on plate 121. This dam, also erected in 1897, is water-tight.

Gauging station No. 17 (plate 122) is located on Garoga Creek, a tributary to Mohawk at Levi Yoran's paper mill, about 4 miles northwest of Fort Plain, where the catchment area above the point of gauging is 80.8 square miles. The dam is the property of Levi Yoran, who uses the developed water power to operate a paper mill. The details may be learned from plate 122. The leakage of this dam is so small as to be negligible.

Gauging station No. 18 (plate 123) is located on Cayadutta Creek, a tributary to Mohawk, at the power station of the Johnstown Electric Light Company, about 2 miles from the city of Johnstown, where the catchment area above the point of gauging is 40 square miles. The dam is the property of the Johnstown Electric Light Company, who use the developed water power to operate their electric-light station. Details of the location are shown on plate 123. This dam is practically water-tight.

Gauging station No. 19 (plate 124) is located on Schoharie Creek, a tributary to Mohawk, at Fort Hunter, where the catchment area above the point of gauging is 946.7 square miles. This dam is the property of the State of New York, its purpose being to divert water from Schoharie Creek into Erie Canal. Conditions as to discharge are similar to those previously described for gauging station No. 11 at Oriskany. The details of the location are shown on plate 124.

This dam was originally a rough timber dam with very heavy leakage. It was repaired and covered with plank in 1895 or 1896, and the leakage considerably lessened, although it is still larger than it should be. A current meter determination of the amount of leakage was made by use of the Price meter already described in discussing gauging station No. 8, and the leakage placed constant at 315 cubic feet per second. This work was done late in the fall of 1898 and should have been checked during the present spring, but the exigencies of rapid completion of the whole work have not permitted of this revision. In view of this large leakage the flows of Schoharie Creek, especially in the lower stages, must, for the present, be considered somewhat approximate. For higher stages the error from this cause is not large.

Gauging station No. 20 (plate 125) is located on Mohawk River at Rexford Flats, where the catchment area above the point of gauging is 3,384.9 square miles. The dam, which is a substantial masonry construction, with timber apron at the front, is the property of the State of New York, its purpose being to divert water from Mohawk River for Erie Canal. The conditions of discharge are the same as described for gauging station No. 11, at Oriskany, and station No. 19, on Schoharie Creek at Fort Hunter. The dam was thoroughly repaired with new coping and partial renewal of timber apron early in the season of 1898. A plan, profile, and section are shown on plate 125. This dam is considered to be water-tight.

Gauging stations Nos. 21, 22, and 23 are, as already stated, on Hudson River at Mechanicville and Fort Edward and on Schroon River at Warrensburg.

Gauging station No. 24 (plate 126) is located on Black River, at Huntingtonville, a suburb of the city of Watertown, where the catchment area above the point of gauging is 1,888.6 square miles. The dam is a substantial timber construction erected in 1896 for the purpose of supplying water power at the pumping station of the Watertown waterworks. According to statements of Frank A. Hinds, C. E., member of the board of water commissioners of Watertown, there is a leakage of 200 cubic feet per second, which has been allowed for in reducing the gaugings. The details of this station are shown on plate 126.

During the months of canal navigation the mean daily flow over the Huntingtonville dam has been increased by an amount equivalent to the diversion from the Upper Black River above the State dam at Forestport for the supply of Black River and Erie canals.

The maximum diversion for canal puposes occurs during the month of July, and for this month the total amount of water diverted may be taken at 13,000 cubic feet per minute.[1] For the month of September, from measurements by Aug. S. Kibbie in 1888, it is found that, with the feeder running at 16,000 cubic feet per minute, there is returned to Black River by lockages, wasteweirs, sluiceways, and feed through lock gates an average amount of 5,000 cubic feet per minute, as nearly as can be determined, the total amount actually diverted being 11,000 cubic feet per minute.[2] The amount of water diverted during the remaining months of canal navigation has been taken as bearing the same proportion to the diversion for the months of July and September, in each case, that exists between the mean depths of evaporation, in inches per month, from a water surface, as observed at Rochester, for the respective months.[3]

In the accompanying table column (3) gives the mean monthly evaporation, in inches, from a floating tub on the Mount Hope reservoir of the Rochester waterworks. Column (2) shows the number of years during which observations have been made for each month.

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[1] Annual Report State Engineer and Surveyor of New York for 1894, p. 239.

[2] Report of the assistant engineer in charge of examinations of the sources of water supply to the Black River and its tributaries. Annual Report of New York State Engineer and Surveyor, 1888, p. 249.

[3] Annual Reports Executive Board of the City of Rochester, N. Y., 1897, p. 74.

Column (4) shows the same thing as column (3) but with the 1897 record included. Column (5) shows the quantity divested in cubic feet per minute, and column (6) the same thing in cubic feet per second. These data were not at hand at the time that the computations for flow of Black River were made, but differ so little from the data used that no changes have been made in the former results.

Month.	Period of observations.	Mean monthly evaporation from a water surface at Rochester, N. Y., in inches.		Diversion of water for the supply of Black River Canal.	
		For the period given in column (2).	For the same period with the 1897 record included.	Cubic feet per minute.	Cubic feet per second.
(1)	(2)	(3)	(4)	(5)	(6)
May	1892-1896	4.05	3.93	11,000	183
June	1892-1896	4.93	4.94	12,000	201
July	1891-1896	5.64	5.47	13,000	216
August	1891-1896	5.28	5.30	12,500	209
September	1891-1896	4.07	4.15	11,000	183
October	1891-1896	3.13	3.16	9,840	164
November	1895-1896	1.51	1.45	7,800	130

The dates of opening and closing of navigation on Black River Canal for the years 1897 and 1898 were as follows: 1897, opened May 20, closed December 1; 1898, opened May 12, closed December 10. These dates have been taken into consideration in allowing for diversion in May and December.

In regard to the foregoing dams over which gaugings have been made, it may be remarked that, taken as a whole, they must be considered fairly satisfactory in this particular—that most of them possess the quality of substantial water-tightness. This quality was made one of the, so far as possible, imperative conditions of the preliminary examination. Before selecting a gauging station on any given stream it was sometimes necessary to examine several dams, the quality of water-tightness being an important consideration in the final decision. On a few of the streams gauged water-tight or nearly water-tight dams do not exist.

The following tabulations give the run-offs of the several streams referred to in the foregoing as gauged during the present work, the run-off of Genesee River being also included at the end:

Comparative tables showing run-offs of streams in New York from September, 1898, to May, 1899, inclusive.

GAUGING STATION NO. 1.

[Run-off of Seneca River at Baldwinsville. Catchment area, 3,103 square miles.]

Date.	Cubic feet per second.	Cubic feet per square mile per second.	Inches on catchment area.	Remarks.
Replenishing period.				
November, 1898	3,137	1.0	1.1	Mean of 19 days.
Storage period.				
December, 1898	2,689	.9	1.0	
January, 1899	2,851	.9	1.1	
February, 1899	1,769	.6	.6	
March, 1899	3,875	1.2	1.4	
April, 1899	4,543	1.5	1.6	
May, 1899	2,568	.8	1.0	
Means and total	3,050	1.0	6.7	

GAUGING STATION NO. 2.

[Run-off of Oswego River at Fulton. Catchment area, 4,915.6 square miles.]

Replenishing period.				
November, 1898	6,220	1.4	1.6	
Storage period.				
December, 1898	5,300	1.1	1.3	
January, 1899	6,150	1.3	1.5	
February, 1899	4,075	.8	.8	
March, 1899	7,830	1.6	1.9	
April, 1899	11,000	2.2	2.5	
May, 1899	6,586	1.1	1.3	
Means and total	6,845	1.4	9.3	

GAUGING STATION NO. 3.

[Run-off of Chittenango Creek at Bridgeport. Catchment area, 306.9 square miles.]

Replenishing period.				
September, 1898	129	0.4	0.5	Mean of 15 days.
October, 1898	320	1.0	1.1	
November, 1898	550	1.7	1.9	
Means and total	333	1.0	3.5	
Storage period.				
December, 1898	530	1.7	2.0	
January, 1899	600	2.0	2.3	
February, 1899	450	1.4	1.5	
March, 1899	711	2.3	2.6	
April, 1899	820	2.7	3.0	
May, 1899	230	.7	.8	
Means and total	563	1.8	12.2	

Comparative tables showing run-offs of streams in New York from September, 1898, to May, 1899, inclusive—Continued.

GAUGING STATION NO. 4.

[Run-off of Oneida Creek at Kenwood. Catchment area, 59 square miles.]

Date.	Cubic feet per second.	Cubic feet per square mile per second.	Inches on catchment area.	Remarks.
Replenishing period.				
October, 1898	76	1.3	1.5	Mean of 27 days.
November, 1898	95	1.6	1.8	
Storage period.				
December, 1898	75	1.3	1.5	
January, 1899	97	1.6	1.9	
February, 1899	79	1.3	1.4	
March, 1899	126	2.1	2.4	
April, 1899	160	2.7	3.1	
May, 1899	58	1.0	1.2	
Means and total	90	1.7	11.5	

GAUGING STATION NO. 6.

[Run-off of West Branch of Fish Creek at McConnellsville. Catchment area, 186.7 square miles.]

Replenishing period.				
September, 1898	108	0.6	0.7	Mean of 18 days.
October, 1898	300	1.7	2.0	
November, 1898	340	1.8	2.1	
Means and total	250	1.3	4.8	
Storage period.				
December, 1898	180	1.0	1.2	
January, 1899	385	2.1	2.4	
February, 1899	170	.9	.9	
March, 1899	530	2.9	3.3	
April, 1899	1,040	5.5	6.1	
May, 1899	215	1.4	1.6	
Means and total	425	2.3	15.5	

GAUGING STATION NO. 7.

[Run-off of East Branch of Fish Creek at Point Rock. Catchment area, 104.3 square miles.]

Replenishing period.				
September, 1898	250	2.4	2.7	Mean of 9 days.
October, 1898	310	3.0	3.5	
November, 1898	380	3.6	4.0	
Means and total	313	3.0	10.2	
Storage period.				
December, 1898	201	1.9	2.2	
January, 1899	209	2.0	2.3	
February, 1899	251	2.4	2.5	
March, 1899	342	3.3	3.8	
April, 1899	751	7.2	8.0	
May, 1899	295	2.8	3.2	
Means and total	340	3.3	22.0	

Comparative tables showing run-offs of streams in New York from September, 1898, to May, 1899, inclusive—Continued.

GAUGING STATION NO. 8.

[Run-off of Salmon River 1 mile above falls. Catchment area, 190.5 square miles.]

Date.	Cubic feet per second.	Cubic feet per square mile per second.	Inches on catchment area.	Remarks.
Replenishing period.				
November, 1898	490	2.6	2.8	
Storage period.				
December, 1898	315	1.6	1.8	
January, 1899	522	2.7	3.1	
February, 1899	200	1.0	1.0	
March, 1899	468	2.4	2.8	
April, 1899	2,220	11.6	12.8	
May, 1899	605	3.2	3.7	
Means and total	722	3.8	25.2	

GAUGING STATION NO. 9.

[Run-off of Mohawk River at Ridge Mills. Catchment area, 152.5 square miles.]

Replenishing period.				
October, 1898	324	2.1	2.4	
November, 1898	356	2.3	2.6	
Storage period.				
December, 1898	210	1.3	1.6	
January, 1899	332	2.2	2.5	
February, 1899	193	1.3	1.4	
March, 1899	430	2.7	3.3	
April, 1899	935	6.1	7.0	
May, 1899	275	1.8	2.1	
Means and total	400	2.6	17.9	

GAUGING STATION NO. 10.

[Run-off of Nine Mile Creek at Stittville. Catchment area, 62.6 square miles.]

Replenishing period.				
September, 1898	398	6.4	7.1	Estimated from mean of 10 days.
October, 1898	98	1.6	1.8	
November, 1898	92	1.5	1.7	
Means and total	196	3.2	10.6	
Storage period.				
December, 1898	135	2.1	2.4	
January, 1899	225	3.6	4.1	
February, 1899	85	1.4	1.5	
March, 1899	210	3.3	3.8	
April, 1899	340	5.4	6.0	
May, 1899	47	.8	.9	
Means and total	174	2.8	18.7	

Comparative tables showing run-offs of streams in New York from September, 1898, to May, 1899, inclusive—Continued.

GAUGING STATION NO. 11.

[Run-off of Oriskany Creek at Oriskany. Catchment area, 144.3 square miles.]

Date.	Cubic feet per second.	Cubic feet per square mile per second.	Inches on catchment area.	Remarks.
Replenishing period.				
October, 1898	325	2.2	2.6	Mean of 16 days.
November, 1898	327	2.3	2.5	
Storage period.				
December, 1898	327	2.3	2.6	
January, 1899	295	2.1	2.4	
February, 1899	291	2.0	2.1	
March, 1899	342	2.3	2.7	
April, 1899	466	3.2	3.6	
May, 1899	119	.9	1.0	
Means and total	307	2.1	14.4	

GAUGING STATION NO. 13.

[Run-off of Sauquoit Creek at New York Mills. Catchment area, 51.5 square miles.]

Replenishing period.				
September, 1898	27	0.5	0.6	Mean of 11 days.
October, 1898	56	1.1	1.2	
November, 1898	57	1.1	1.2	
Means and total	47	.9	3.0	
Storage period.				
December, 1898	57	1.1	1.3	
January, 1899	58	1.1	1.3	
February, 1899	58	1.1	1.2	
March, 1899	111	2.2	2.5	
April, 1899	127	2.5	2.8	
May, 1899	38	.7	.8	
Means and total	75	1.4	9.9	

GAUGING STATION NO. 14.

[Run-off of West Canada Creek at Middleville. Catchment area, 518.7 square miles.]

Replenishing period.				
October, 1898	1,071	2.1	2.3	
November, 1898	1,125	2.2	2.5	
Storage period.				
December, 1898	922	1.8	2.1	
January, 1899	1,028	2.0	2.3	
February, 1899	1,422	2.9	2.9	
March, 1899	1,058	2.0	2.2	
April, 1899	3,365	6.5	7.2	
May, 1899	1,456	2.8	3.2	
Means and total	1,550	3.0	21.0	

Comparative tables showing run-offs of streams in New York from September, 1898, to May, 1899, inclusive—Continued.

GAUGING STATION NO. 15.

[Run-off of Mohawk River at Little Falls. Catchment area, 1,306 square miles.]

Date.	Cubic feet per second.	Cubic feet per square mile per second.	Inches on catchment area.	Remarks.
Replenishing period.				
September, 1898	2,378	1.8	2.0	Mean of 8 days.
October, 1898	2,493	1.9	2.2	
November, 1898	2,891	2.2	2.5	
Means and total	2,586	2.0	6.7	
Storage period.				
December, 1898	2,036	1.6	1.8	
January, 1899	2,753	2.1	2.4	
February, 1899	1,510	1.2	1.2	
March, 1899	3,757	2.9	3.3	
April, 1899	8,102	6.2	6.9	
May, 1899	2,651	2.0	2.3	
Means and total	3,475	2.7	18.0	

GAUGING STATION NO. 16.

[Run-off of East Canada Creek at Dolgeville. Catchment area, 255.6 square miles.]

Replenishing period.				
September, 1898	638	2.5	2.8	Mean of 8 days.
October, 1898	581	2.3	2.4	
November, 1898	689	2.7	3.0	
Means and total	635	2.5	8.8	
Storage period.				
December, 1898	564	2.2	2.5	Mean of 18 days.
January, 1899	653	2.6	2.9	
February, 1899	439	1.7	1.8	
March, 1899	519	2.3	2.6	
April, 1899	1,978	7.7	8.6	
May, 1899	633	2.5	2.8	
Means and total	806	3.1	21.3	

GAUGING STATION NO. 17.

[Run-off of Garoga Creek, 4 miles above Fort Plain. Catchment area, 80.8 square miles.]

Replenishing period.				
October, 1898	140	1.7	2.0	
November, 1898	190	2.3	2.6	
Storage period.				
December, 1898	77	.9	1.1	
January, 1899	43	.5	.6	
February, 1899	47	.6	.6	
March, 1899	160	2.0	2.3	
April, 1899	500	6.1	6.8	
May, 1899	99	1.2	1.4	
Means and total	155	1.8	12.8	

Comparative tables showing run-offs of streams in New York from September, 1898, to May, 1899, inclusive—Continued.

GAUGING STATION NO. 18.

[Run-off of Cayadutta Creek at Johnstown. Catchment area, 40 square miles.]

Date.	Cubic feet per second.	Cubic feet per square mile per second.	Inches on catchment area.	Remarks.
Replenishing period.				
September, 1898	16	0.4	0.3	Mean of 3 days.
October, 1898	60	1.5	1.7	
November, 1898	80	2.0	2.2	
Means and total	52	1.3	4.2	
Storage period.				
December, 1898	44	1.1	1.3	
January, 1899	39	1.0	1.1	
February, 1899	31	.8	.8	
March, 1899	74	1.8	2.1	
April, 1899	220	5.5	6.1	
May, 1899	31	.8	.9	
Means and total	74	1.8	12.3	

GAUGING STATION NO. 19.

[Run off of Schoharie Creek at Fort Hunter. Catchment area, 946.7 square miles.]

Replenishing period.				
September, 1898	409	0.4	0.5	Mean of 7 days.
October, 1898	1,422	1.5	1.7	
November, 1898	2,447	2.6	2.9	
Means and total	1,426	1.5	5.1	
Storage period.				
December, 1898	1,853	2.0	2.3	
January, 1899	2,584	2.7	3.2	
February, 1899	2,224	2.3	2.4	
March, 1899	4,072	4.3	5.0	
April, 1899	4,380	4.6	5.2	
May, 1899	858	.9	1.0	
Means and total	2,662	2.8	19.1	

GAUGING STATION NO. 20.

[Run-off of Mohawk River at Rexford Flats. Catchment area, 3,384.9 square miles.]

Storage period.				
December, 1898	4,550	1.3	1.5	Mean of 24 days.
January, 1899	5,850	1.7	2.0	
February, 1899	4,000	1.2	1.3	
March, 1899	9,250	2.7	3.1	
April, 1899	17,400	5.1	5.7	
May, 1899	4,150	1.2	1.4	
Means and total	7,537	2.2	15.0	

Comparative tables showing run-offs of streams in New York from September, 1898, to May, 1899, inclusive—Continued.

GAUGING STATION NO. 21.

[Run-off of Hudson River at Mechanicville. Catchment area, 4,500 square miles.]

Date.	Cubic feet per second.	Cubic feet per square mile per second.	Inches on catchment area.	Remarks.
Replenishing period.				
September, 1898	3,872	0.9	1.0	
October, 1898	7,895	1.8	2.0	
November, 1898	9,243	2.0	2.3	
Means and total	7,013	1.6	5.3	
Storage period.				
December, 1898	5,436	1.2	1.4	
January, 1899	6,668	1.5	1.7	
February, 1899	5,258	1.2	1.2	
March, 1899	9,618	2.1	2.5	
April, 1899	23,645	5.2	5.9	
May, 1899	9,752	2.2	2.5	
Means and total	10,070	2.2	15.2	

GAUGING STATION NO. 24.

[Run-off of Black River at Huntingtonville Dam. Catchment area, 1,889 square miles.]

Replenishing period.				
September, 1898	1,744	0.9	1.0	
October, 1898	3,607	1.9	2.2	
November, 1898	4,510	2.4	2.7	
Means and total	3,400	1.7	5.9	
Storage period.				
December, 1898	2,752	1.5	1.7	
January, 1899	4,704	2.5	2.9	
February, 1899	2,381	1.3	1.3	
March, 1899	5,112	2.7	3.1	
April, 1899	14,172	7.5	8.4	
May, 1899	5,840	3.1	3.6	
Means and total	5,903	3.1	20.9	

[Run-off of Genesee River at the Johnston and Seymour Dam, Rochester. Catchment area, 2,365 square miles.]

Replenishing period.				
September, 1898	615	0.3	0.3	
October, 1898	1,180	.5	.6	
November, 1898	2,295	1.0	1.1	
Means and total	1,361		2.0	
Storage period.				
December, 1898	2,440	1.0	1.2	
January, 1899	3,660	1.5	1.7	
February, 1899	1,650	.7	.7	
March, 1899	3,400	1.4	1.7	
April, 1899	3,080	1.3	1.4	
May, 1899	1,200	.5	.6	
Means and total	2,613	1.1	7.4	

The foregoing gaugings, although covering a short period, have still been of considerable value in helping to assign streams drawn upon for water supply to their proper category. The run-offs of the storage period, December to May, inclusive, are complete for all the stations and by comparison with Hudson and Genesee rivers for the cotemporaneous period show at once the approximate place of these streams as regards water yield.

ON METHODS OF COMPUTING FLOW OVER DAMS AT THE SEVERAL GAUGING STATIONS.

On a preceding page it has been pointed out that the computation of flow over dams whose profiles depart materially from the form of a standard weir has been, for lack of data, in a very unsatisfactory state. This fact was very strongly impressed upon the author in 1896, when he constructed a sharp-crested weir on Genesee River and obtained comparative gaugings between the weir and an irregular crested-timber dam a short distance below. An account of the Genesee River weir and the comparative results obtained may be found in the report on Genesee River storage in the Annual Report of the State Engineer and Surveyor of New York for 1896, pages 715–719.

In order to show the variations between different standard formulæ in use for computing flow over dams, plate 127 has been prepared, whereon are exhibited Bazin's and Francis's formulæ for sharp-crested weirs, Francis's formula for dam on the Merrimac River at Lawrence, Mass., Frizell's formula for a flat-crested weir, Mullin's formula as used by the East Indian engineers, and the results of Fteley and Stearns's experiments as applied to a flat-crested weir 2 feet wide, as well as Bazin's series, No. 115, for a flat-crested weir 6.56 feet in width. Plate 127 is self-explanatory.

Beginning in 1888 and continuing in the years 1890, 1891, 1894, 1896, and 1898, H. Bazin, inspecteur-general des Ponts et Chaussees, has published in the Annales des Ponts et Chaussées the results of an extended series of new experiments on flows over weirs and dams, which are in many respects the most complete of any thus far made. The experiments of Messrs. Fteley and Stearns, as recorded in the transactions of the American Society of Civil Engineers for January, February, and March, 1883, had indeed shown the material effect of width of crest on discharge over weirs, but it was reserved for Bazin to elucidate the whole question in a masterly series of experiments, which are, as regards detail and minute research, unparalleled.

The experiments on flows over dams of irregular profile are given in the second number of Annales des Ponts et Chaussées for 1898, which came to hand in September, just when the arrangements for gaugings, as described in the preceding chapter, were in progress. It was at once recognized that Bazin's work was in many respects revolutionary, and reasoning on the line adopted for the present work of utilizing all available data, on consultation with your Board it was determined to apply his work to the several gauging stations.

Before proceeding to describe the specific application made we may refer briefly to the earlier papers of 1888, etc., in which Bazin has described his experiments on standard weirs.

In the beginning of his first paper Bazin remarks that the theory of the weir is the least advanced of all branches of hydraulics. The coefficients employed in practice vary between such wide limits that in most cases we are unable to make a rational selection from the many numerical values assigned to them.

The problem, he says, is in fact a complicated one, being connected on the one hand with the theory of flow through orifices and on the other with that of open channels. The value of the coefficients in each case is influenced by many elements. Thus we ought to consider:

1. The velocity of approach—that is, the velocity with which the upstream water reaches the weir—the effect of which can not be neglected in weirs of small height.

2. The contraction of the vertical section of the stream at the weir, the amount depending upon the height of the weir and upon the form of the crest.

3. The lateral contraction, which, though unimportant in weirs of great length, seriously modifies the results in shorter weirs.

As a further condition Bazin points out that when the downstream channel has a width equal to the length of the weir, so that the overflowing sheet of water or nappe touches at the sides, thus preventing free admission of water under the nappe, there occur special phenomena greatly affecting the flow.

Bazin's earlier papers are specially devoted to a detailed investigation of these several points. Space will not be taken here to describe his experiments in detail. The original data may be found in the Annales des Ponts et Chaussées for the years already cited. A translation of the earlier numbers has also been made by Messrs. Arthur Marichal and John C. Trautwine, jr., members of the Engineers' Club, of Philadelphia, and which may be found in the proceedings of that club for January, 1890, July, 1892, October, 1892, and April, 1893.

Bazin's method of experimentation may, however, be briefly referred to. A standard weir was set up at the head of a long chamber, in which the actual volume passing over was measured a sufficient number of times to give averages which Bazin considers are accurate to within probably less than 1 per cent. Having established in this way the values of the coefficients for a standard weir, with heads varying from about 0.164 foot to 1.969 feet, the experiments on weirs of irregular profiles were made by placing each experimental weir below the standard weir and observing the heads synchronously on each. In these experiments a steady current was established in the channel and observations made of the known volume passing over the standard weir, and which volume also passed over the weir under investigation lower down. If we let H and h denote, respectively, the head upon the standard weir and that upon the lower weir, L and l their corresponding lengths, and M and m the coefficients of discharge, and then, adopting provisionally formula (1) for the standard weir,

$$Q = MLH\sqrt{2gH} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (1)$$

and similarly for the lower weir,

$$Q = mlh\sqrt{2gh} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (2)$$

Equating these two values of Q we have

$$MLH\sqrt{H}\sqrt{2g} = mlh\sqrt{h}\sqrt{2g}, \text{ or}$$

$$MLH^{\frac{3}{2}} = mlh^{\frac{3}{2}}$$

from which we deduce the value of m:

$$m = M\left(\frac{L}{l}\right) \times \left(\frac{H}{h}\right)^{\frac{3}{2}}$$

and conversely

$$M = m\left(\frac{l}{L}\right) \times \left(\frac{h}{H}\right)^{\frac{3}{2}}$$

As already stated, Bazin's preliminary gauging operations gave, once for all, the coefficient M for the standard weir for each value of H. The ratio $\frac{L}{l}$, which is very nearly unity, remains constant for all the experiments of any one series; and we have, therefore, only to measure the heads H and h in order to obtain the coefficient m. Fteley and Stearns experimented somewhat on the influence of the height of the weir upon the flow, and probably as interesting a point as any brought out by Bazin's extended experiments is the considerable influence of this element upon the flow. After presenting the details of experiments on weirs of various heights and for various heads between the limits stated, Bazin gives a table of values of the coefficient m for weirs ranging from a height of 0.656 foot to 6.56 feet. Column (11) of this table, as reproduced below, gives the limiting value of m, which equals the coefficient $\varkappa$ (represented by n) of Bazin's formula, and which represents the value of m for a weir of infinite height, or of such a height that the height of the weir above the bottom of the channel has no further effect upon the flow. As will be seen by examining this table, the influence is only slight beyond 6.56 feet.

The formula for a sharp-crested weir without end contractions as ordinarily used in the United States is that of Francis—

$$Q = ClH^{\frac{3}{2}}$$

In this formula it is necessary to take into account the velocity of approach. We may consider h as without corrections while in H all corrections are made.

Values of the coefficient m in the formula $Q = m\,l\,h\sqrt{2gh}$, *for a sharp-crested weir without lateral contraction, the air being admitted freely beneath the overflowing sheet or nappe.*

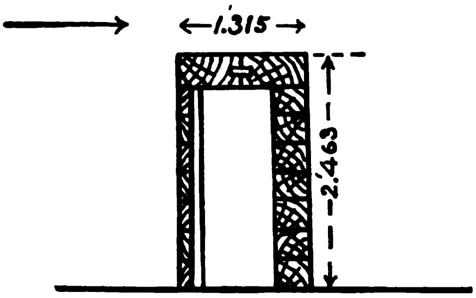
Head equals *h* in feet.	Values of the coefficient *m*, corresponding to the height, *p*, of the weir above the bottom of the channel.									Limiting value of *m* equals coefficient *n*,
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Value of *p*. in feet.	0.656	0.984	1.312	1.640	1.968	2.624	3.280	4.920	6.560	∞
0.164	0.458	0.453	0.451	0.450	0.449	0.449	0.449	0.448	0.448	0.4481
0.197	0.456	0.450	0.447	0.445	0.445	0.444	0.443	0.443	0.443	0.4427
0.230	0.455	0.448	0.445	0.443	0.442	0.441	0.440	0.440	0.439	0.4391
0.262	0.456	0.447	0.443	0.441	0.440	0.438	0.438	0.437	0.437	0.4363
0.295	0.457	0.447	0.442	0.440	0.438	0.436	0.436	0.435	0.434	0.4340
Means.	0.456	0.449	0.446	0.444	0.443	0.442	0.441	0.441	0.440	0.4400
0.328	0.459	0.447	0.442	0.439	0.437	0.435	0.434	0.433	0.433	0.4322
0.394	0.462	0.448	0.442	0.438	0.436	0.433	0.432	0.430	0.430	0.4291
0.459	0.466	0.450	0.443	0.438	0.435	0.432	0.430	0.428	0.428	0.4267
0.525	0.471	0.453	0.444	0.438	0.435	0.431	0.429	0.427	0.426	0.4246
0.591	0.475	0.456	0.445	0.439	0.435	0.431	0.428	0.426	0.425	0.4229
Means.	0.467	0.451	0.443	0.438	0.436	0.432	0.431	0.429	0.428	0.4271
0.656	0.480	0.459	0.447	0.440	0.436	0.431	0.428	0.425	0.423	0.4215
0.722	0.484	0.462	0.449	0.442	0.437	0.431	0.428	0.424	0.423	0.4203
0.787	0.488	0.465	0.452	0.444	0.438	0.432	0.428	0.424	0.422	0.4194
0.853	0.492	0.468	0.455	0.446	0.440	0.432	0.429	0.424	0.422	0.4187
0.919	0.496	0.472	0.457	0.448	0.441	0.433	0.429	0.424	0.422	0.4181
Means.	0.488	0.465	0.452	0.444	0.438	0.432	0.428	0.424	0.422	0.4196
0.984	0.500	0.475	0.460	0.450	0.443	0.434	0.430	0.424	0.421	0.4147
1.050	0.500	0.478	0.462	0.452	0.444	0.436	0.430	0.424	0.421	0.4168
1.116	0.500	0.481	0.464	0.454	0.446	0.437	0.431	0.424	0.421	0.4162
1.181	0.500	0.483	0.467	0.456	0.448	0.438	0.432	0.424	0.421	0.4156
1.247	0.500	0.486	0.469	0.458	0.449	0.439	0.432	0.424	0.421	0.4150
Means.	0.500	0.481	0.464	0.454	0.446	0.437	0.431	0.424	0.421	0.4162
1.312	0.500	0.489	0.472	0.459	0.451	0.440	0.433	0.424	0.421	0.4144
1.378	0.500	0.491	0.474	0.461	0.452	0.441	0.434	0.425	0.421	0.4139
1.444	0.500	0.494	0.476	0.463	0.454	0.442	0.435	0.425	0.421	0.4134
1.509	0.500	0.496	0.478	0.465	0.456	0.443	0.435	0.425	0.421	0.4128
1.575	0.500	0.496	0.480	0.467	0.457	0.444	0.436	0.425	0.421	0.4122
Means.	0.500	0.493	0.476	0.463	0.454	0.442	0.435	0.425	0.421	0.4133
1.640	0.500	0.496	0.482	0.468	0.459	0.445	0.437	0.426	0.421	0.4118
1.706	0.500	0.496	0.483	0.470	0.460	0.446	0.438	0.426	0.421	0.4112
1.772	0.500	0.496	0.485	0.472	0.461	0.447	0.438	0.426	0.421	0.4107
1.837	0.500	0.496	0.487	0.473	0.463	0.448	0.439	0.427	0.421	0.4101
1.903	0.500	0.496	0.489	0.475	0.464	0.449	0.440	0.427	0.421	0.4096
1.969	0.500	0.496	0.490	0.476	0.466	0.451	0.441	0.427	0.421	0.4092
Means.	0.500	0.496	0.486	0.472	0.462	0.448	0.436	0.427	0.421	0.4104

In regard to the accuracy of the coefficients as given by the preceding tabulation Bazin remarks that except in the unusual case of a very low weir, which should always be avoided, the preceding table will give the coefficient *m* within 1 per cent; provided, however, that the arrangements of his standard weir be exactly reproduced. It is also pointed out as especially important that the admission of air behind the falling sheet be perfectly assured, as otherwise *m* may vary within much wider limits.

The following tables give in English measures the results of Bazin's experiments on weirs of irregular profiles from series No. 113 to No. 193, inclusive, except that a few of the series have been omitted from these tables:

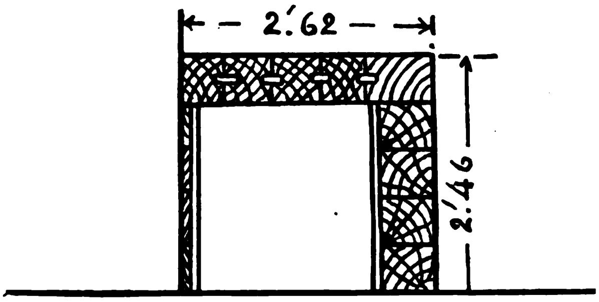
SPECIAL EXPERIMENTS ON WEIRS WITH WIDE CRESTS.[1]

BAZIN'S SERIES NO. 113.



Number of experiment.	h = depth on crest, in feet.	m = coefficient of discharge.	Number of experiment.	h = depth on crest, in feet.	m = coefficient of discharge.
1	0.208	0.3294	11	0.936	0.3547
2	0.289	0.3318	12	0.989	0.3593
3	0.363	0.3307	13	1.035	0.3628
4	0.443	0.3302	14	1.076	0.3660
5	0.518	0.3321	15	1.114	0.3682
6	0.592	0.3348	16	1.159	0.3734
7	0.667	0.3378	17	1.197	0.3758
8	0.736	0.3427	18	1.252	0.3821
9	0.805	0.3468	19	1.320	0.3877
10	0.863	0.3494			

BAZIN'S SERIES NO. 114.



Number of experiment.	h = depth on crest, in feet.	m = coefficient of discharge.	Number of experiment.	h = depth on crest, in feet.	m = coefficient of discharge.
1	0.204	0.3073	10	0.882	0.3300
2	0.290	0.3167	11	0.958	0.3316
3	0.352	0.3229	12	1.034	0.3336
4	0.433	0.3245	13	1.112	0.3351
5	0.504	0.3233	14	1.171	0.3361
6	0.578	0.3241	15	1.243	0.3398
7	0.657	0.3270	16	1.301	0.3407
8	0.725	0.3272	17	1.384	0.3440
9	0.810	0.3281			

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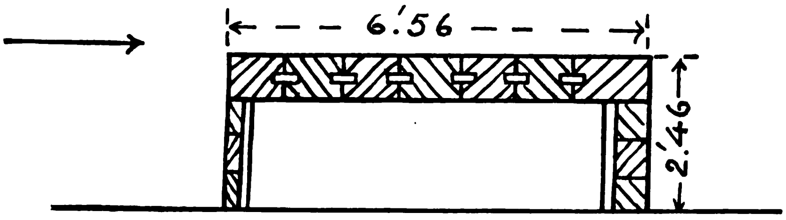
[1] For a considerable extension of these data see Trans. Am. Soc. C. E., paper No. 884, On the Flow of Water Over Dams, Vol. XLIV, December, 1900.

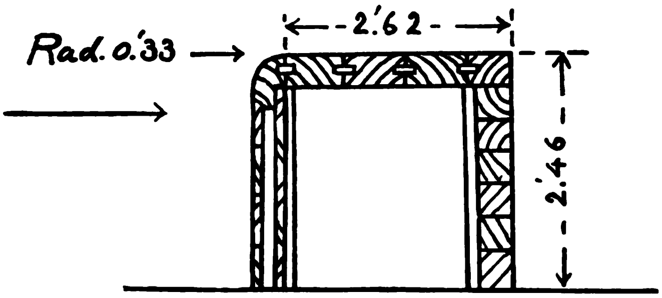
SPECIAL EXPERIMENTS ON WEIRS WITH WIDE CRESTS—Continued.

BAZIN'S SERIES NO. 115.



Number of experiment.	h = depth on crest, in feet.	m = coefficient of discharge.	Number of experiment.	h = depth on crest, in feet.	m = coefficient of discharge.
1	0.196	0.2747	11	0.948	0.3245
2	0.264	0.3004	12	1.023	0.3250
3	0.342	0.3047	13	1.097	0.3281
4	0.415	0.3123	14	1.178	0.3294
5	0.495	0.3119	15	1.280	0.3302
6	0.566	0.3184	16	1.330	0.3342
7	0.638	0.3173	17	1.388	0.3348
8	0.716	0.3194	18	1.424	0.3365
9	0.792	0.3243	19	1.467	0.3362
10	0.871	0.3245			

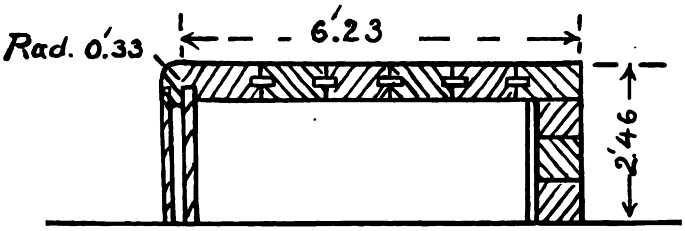
BAZIN'S SERIES NO. 116.



Number of experiment.	h = depth on crest, in feet.	m = coefficient of discharge.	Number of experiment.	h = depth on crest, in feet.	m = coefficient of discharge.
1	0.177	0.3372	10	0.781	0.3742
2	0.225	0.3528	11	0.849	0.3764
3	0.296	0.3607	12	0.917	0.3765
4	0.367	0.3637	13	0.988	0.3797
5	0.435	0.3679	14	1.053	0.3813
6	0.504	0.3707	15	1.120	0.3841
7	0.537	0.3731	16	1.185	0.3859
8	0.639	0.3753	17	1.251	0.3863
9	0.713	0.3734	18	1.317	0.3888

SPECIAL EXPERIMENTS ON WEIRS WITH WIDE CRESTS—Continued.

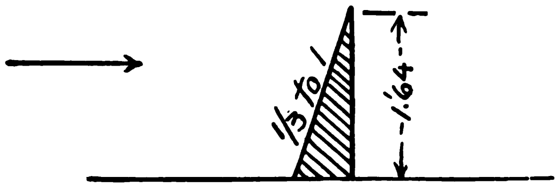
BAZIN'S SERIES NO. 117.



Number of experiment.	h = depth on crest, in feet.	m = coefficient of discharge.	Number of experiment.	h = depth on crest, in feet.	m = coefficient of discharge.
1	0.158	0.2741	10	0.771	0.3604
2	0.204	0.3287	11	0.834	0.3629
3	0.289	0.3207	12	0.912	0.3649
4	0.361	0.3286	13	0.989	0.3671
5	0.426	0.3396	14	1.064	0.3680
6	0.494	0.3452	15	1.129	0.3678
7	0.562	0.3533	16	1.197	0.3701
8	0.635	0.3521	17	1.267	0.3712
9	0.708	0.3563	18	1.336	0.3731

FIRST GROUP.—*Face of the weir, on the downstream side, vertical or nearly vertical.*

BAZIN'S SERIES NO. 125.

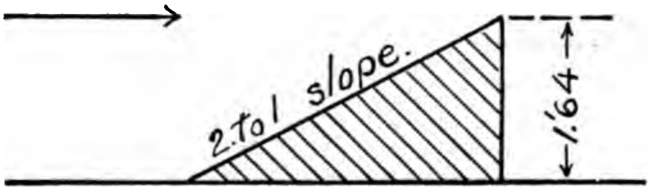


Number of experiment.	h = depth on crest, in feet.	m = coefficient of discharge.	Number of experiment.	h = depth on crest, in feet.	m = coefficient of discharge.
1	0.318	a 0.4516	11	0.878	0.5047
2	0.383	0.4530	12	0.850	0.4898
3	0.439	0.4604	13	1.006	0.4966
4	0.492	0.4715	14	1.077	0.4954
5	0.532	0.4978	15	1.140	0.4905
6	0.569	b 0.5258	16	1.190	0.4919
7	0.633	0.5178	17	1.266	0.4892
8	0.691	0.5187	18	1.328	0.4883
9	0.752	0.5100	19	1.395	0.4863
10	0.818	0.5082			

a Nappe depressed. b Nappe wetted underneath.

First Group.—*Face of the weir, on the downstream side, vertical or nearly vertical*—Continued.

BAZIN'S SERIES NO. 128.

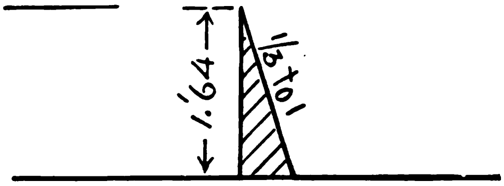


Number of experiment.	h = depth on crest, in feet.	m = coefficient of discharge.	Number of experiment.	h = depth on crest, in feet.	m = coefficient of discharge.
1	0.295	[a]0.5015	11	0.860	0.5234
2	0.360	0.5028	12	0.920	0.5233
3	0.413	0.5024	13	0.981	0.5203
4	0.467	0.5138	14	1.040	0.5228
5	0.520	0.5205	15	1.105	0.5175
6	0.567	[b]0.5332	16	1.164	0.5197
7	0.627	0.5256	17	1.222	0.5170
8	0.684	0.5238	18	1.284	0.5187
9	0.740	0.5251	19	1.351	0.5142
10	0.804	0.5244			

[a] Nappe depressed.

[b] Nappe wetted underneath.

BAZIN'S SERIES NO. 127.[a]

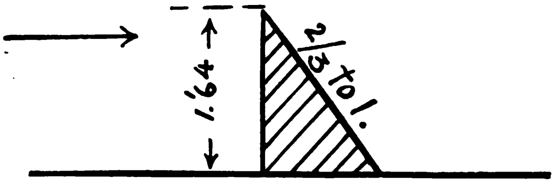


Number of experiment.	h = depth on crest, in feet.	m = coefficient of discharge.	Number of experiment.	h = depth on crest, in feet.	m = coefficient of discharge.
1	0.324	[b]0.4326	11	0.896	0.4895
2	0.389	0.4384	12	0.961	0.4885
3	0.449	0.4419	13	1.033	0.4812
4	0.509	0.4454	14	1.093	0.4823
5	0.561	0.4606	15	1.166	0.4720
6	0.608	0.4728	16	1.228	0.4746
7	0.653	0.4933	17	1.292	0.4729
8	0.697	[c]0.5072	18	1.360	0.4726
9	0.764	0.4989	19	1.424	0.4715
10	0.831	0.4935			

[a] See Bazin's observations relative to the behavior of the nappe for series Nos. 127 and 128.
[b] Nappe depressed.
[c] Nappe wetted underneath.

FIRST GROUP.—*Face of the weir, on the downstream side, vertical or nearly vertical*—Continued.

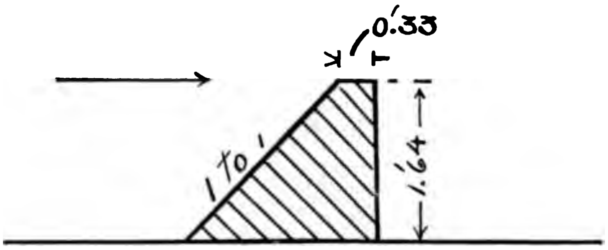
BAZIN'S SERIES NO. 128.[a]



Number of experiment.	h = depth on crest, in feet.	m = coefficient of discharge.	Number of experiment.	h = depth on crest, in feet.	m = coefficient of discharge.
1	0.295	[b]0.5015	12	0.890	[c]0.4909
2	0.353	0.5104	13	0.925	0.4955
3	0.407	0.5090	14	0.967	0.4849
4	0.464	0.5107	15	1.023	0.4834
5	0.526	0.5068	16	1.096	0.4820
6	0.580	0.5159	17	1.166	0.4766
7	0.626	0.5183	18	1.230	0.4758
8	0.692	0.5179	19	1.294	0.4725
9	0.787	0.5156	20	1.360	0.4733
10	0.805	0.5178	21	1.430	0.4696
11	0.843	0.5133			

[a] See Bazin's observations relative to the behavior of the nappe for series Nos. 127 and 128.
[b] Nappe adhering.
[c] Nappe wetted underneath.

BAZIN'S SERIES NO. 129.

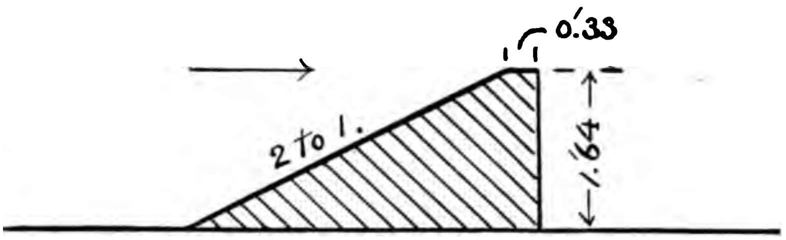


Number of experiment.	h = depth on crest, in feet.	m = coefficient of discharge.	Number of experiment.	h = depth on crest, in feet.	m = coefficient of discharge.
1	0.343	[a]0.4064	11	0.885	0.5029
2	0.399	0.4225	12	0.943	0.5079
3	0.456	0.4343	13	0.995	0.5116
4	0.511	0.4463	14	1.047	0.5155
5	0.565	0.4577	15	1.102	0.5187
6	0.612	[b]0.4722	16	1.163	0.5174
7	0.665	0.4778	17	1.212	0.5236
8	0.726	0.4838	18	1.266	0.5263
9	0.774	0.4952	19	1.327	0.5276
10	0.830	0.4982			

[a] Nappe depressed.
[b] Nappe wetted underneath and attached to flat crest.

FIRST GROUP.—*Face of the weir, on the downstream side, vertical or nearly vertical*—Continued.

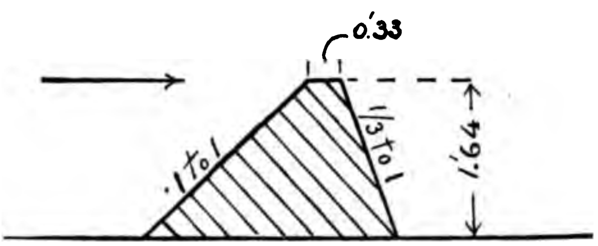
BAZIN'S SERIES NO. 130.



Number of experiment.	h = depth on crest, in feet.	m = coefficient of discharge.	Number of experiment.	h = depth on crest, in feet.	m = coefficient of discharge.
1	0.274	[a] 0.4037	12	0.898	0.4893
2	0.336	0.4138	13	0.956	0.4949
3	0.396	0.4213	14	1.011	0.4970
4	0.452	0.4339	15	1.069	0.4988
5	0.510	0.4458	16	1.123	0.5011
6	0.565	0.4546	17	1.187	0.5031
7	0.618	[b] 0.4663	18	1.240	0.5051
8	0.672	0.4694	19	1.299	0.5074
9	0.728	0.4769	20	1.342	0.5105
10	0.785	0.4801	21	1.406	0.5134
11	0.837	0.4882			

[a] Nappe depressed or adhering, but unstable.
[b] Nappe wetted underneath and attached to flat crest.

BAZIN'S SERIES NO. 131.

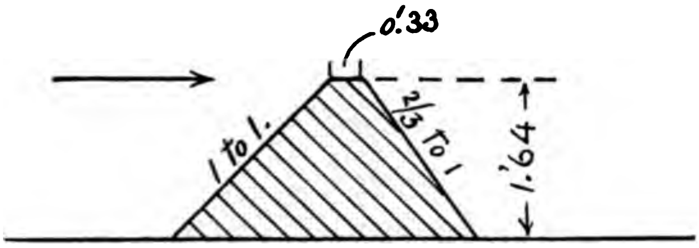


Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.347	[a] 0.3989	12	0.889	0.4997
2	0.336	[b] 0.4140	13	0.943	0.5048
3	0.395	0.4298	14	0.998	0.5090
4	0.450	0.4326	15	1.046	0.5128
5	0.504	0.4443	16	1.098	0.5172
6	0.564	0.4611	17	1.161	0.5167
7	0.610	0.4755	18	1.213	0.5226
8	0.667	0.4770	19	1.264	0.5249
9	0.720	0.4882	20	1.333	0.5242
10	0.773	[c] 0.4937	21	1.394	0.5234
11	0.835	0.4948			

[a] Nappe depressed.
[b] Adhering nappe.
[c] Nappe wetted underneath and attached to flat crest.

First Group.—*Face of the weir, on the downstream side, vertical or nearly vertical*—Continued.

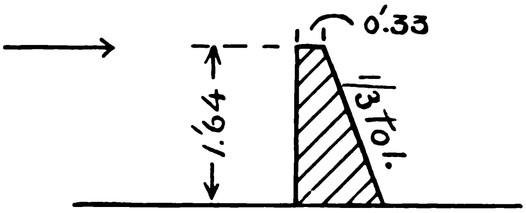
BAZIN'S SERIES NO. 132.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.337	*a* 0.4128	11	0.874	0.5108
2	0.398	0.4251	12	0.926	0.5180
3	0.453	0.4344	13	0.974	0.5237
4	0.509	0.4488	14	1.047	*b* 0.5136
5	0.563	0.4600	15	1.099	0.5174
6	0.619	0.4683	16	1.165	0.5177
7	0.665	0.4788	17	1.212	0.5225
8	0.719	0.4876	18	1.271	0.5238
9	0.779	0.4921	19	1.328	0.5280
10	0.826	0.5029			

a Nappe adhering.
b Nappe wetted underneath and attached to flat crest.

BAZIN'S SERIES NO. 133.

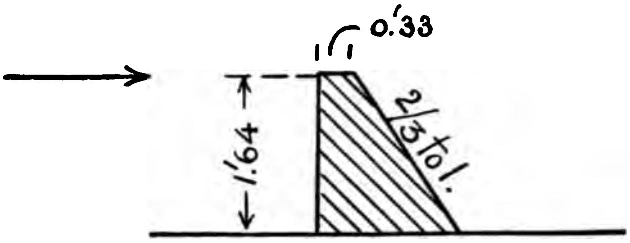


Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.349	*a* 0.3846	12	0.870	*c* 0.5122
2	0.408	0.4028	13	0.928	0.5151
3	0.400	*b* 0.4127	14	0.978	0.5204
4	0.456	0.4263	15	1.033	0.5224
5	0.508	0.4445	16	1.085	0.5242
6	0.565	0.4540	17	1.205	*d* 0.4889
7	0.610	0.4692	18	1.283	0.4794
8	0.666	0.4775	19	1.276	0.4842
9	0.707	0.4922	20	1.346	0.4793
10	0.767	0.4979	21	1.415	0.4783
11	0.816	0.5079			

a Nappe depressed.
b Nappe adhering.
c Nappe wetted underneath and attached to flat crest.
d Nappe wetted underneath, but detached from flat crest.

First Group.—*Face of the weir, on the downstream side, vertical or nearly vertical*—Continued.

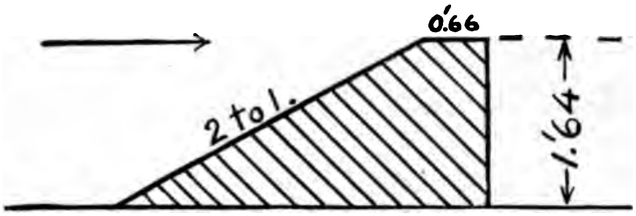
BAZIN'S SERIES NO. 134.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.350	*a* 0.3880	11	0.866	0.5186
2	0.405	0.4090	12	0.909	0.5280
3	0.458	0.4228	13	0.964	0.5334
4	0.513	0.4378	14	1.011	0.5380
5	0.567	0.4515	15	1.060	0.5427
6	0.615	0.4633	16	1.118	0.5463
7	0.664	0.4751	17	1.253	*b* 0.4957
8	0.714	0.4867	18	1.348	0.4804
9	0.767	0.4970	19	1.574	0.4764
10	0.815	0.5061	20	1.489	0.4712

a Nappe adhering. *b* Nappe wetted underneath, but detached from flat crest.

BAZIN'S SERIES NO. 135.

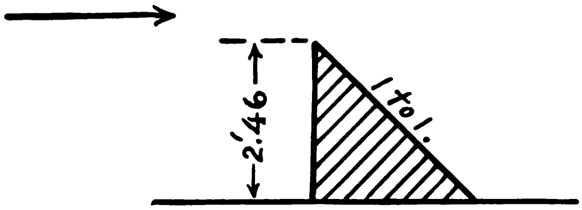


Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.224	*a* 0.3727	12	0.892	0.4498
2	0.292	0.3839	13	0.939	0.4575
3	0.353	0.3962	14	1.011	0.4614
4	0.422	0.3981	15	1.063	0.4657
5	0.480	0.4071	16	1.119	0.4695
6	0.541	0.4127	17	1.175	0.4740
7	0.597	0.4243	18	1.230	0.4757
8	0.657	*b* 0.4264	19	1.275	0.4839
9	0.712	0.4347	20	1.346	0.4824
10	0.773	0.4394	21	1.410	0.4847
11	0.829	0.4439			

a Nappe depressed. *b* Nappe wetted underneath.

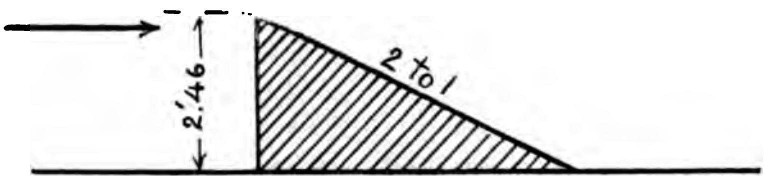
Second Group.—*Face of the weir, on the upstream side, vertical or nearly vertical.*

BAZIN'S SERIES NO. 136.



Number of experiment. (1)	h=depth on crest, in feet. (2)	m=coefficient of discharge. (3)	Number of experiment. (1)	h=depth on crest, in feet. (2)	m=coefficient of discharge. (3)
1	0.183	0.4865	12	0.830	0.4948
2	0.244	0.4815	13	0.887	0.4941
3	0.304	0.4803	14	0.953	0.4962
4	0.364	0.4814	15	1.010	0.4950
5	0.424	0.4831	16	1.068	0.4979
6	0.484	0.4820	17	1.122	0.4975
7	0.542	0.4842	18	1.179	0.4997
8	0.597	0.4854	19	1.244	0.4993
9	0.658	0.4874	20	1.299	0.5005
10	0.713	0.4886	21	1.361	0.5023
11	0.776	0.4900			

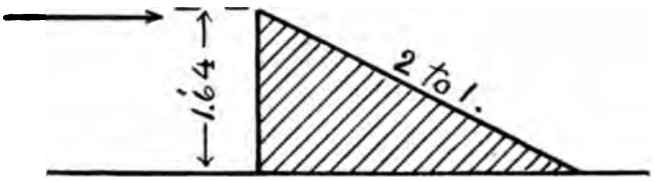
BAZIN'S SERIES NO. 137.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h=depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.268	0.4324	10	0.822	0.4441
2	0.339	0.4310	11	0.887	0.4445
3	0.391	0.4359	12	0.946	0.4513
4	0.451	0.4323	13	1.012	0.4476
5	0.513	0.4400	14	1.078	0.4505
6	0.578	0.4377	15	1.142	0.4490
7	0.637	0.4378	16	1.201	0.4517
8	0.700	0.4434	17	1.262	0.4520
9	0.765	0.4437	18	1.322	0.4543

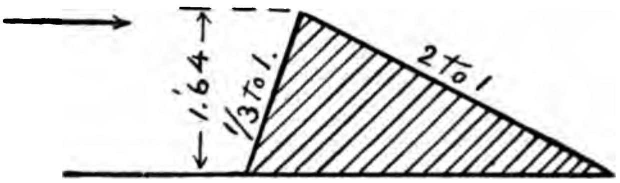
Second Group.—*Face of the weir, on the upstream side, vertical or nearly vertical*—Continued.

BAZIN'S SERIES NO. 138.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.194	0.4450	12	0.873	0.4637
2	0.263	0.4357	13	0.927	0.4643
3	0.327	0.4344	14	0.992	0.4683
4	0.391	0.4356	15	1.045	0.4743
5	0.447	0.4429	16	1.110	0.4707
6	0.510	0.4524	17	1.176	0.4716
7	0.571	0.4511	18	1.233	0.4746
8	0.626	0.4622	19	1.289	0.4758
9	0.685	0.4565	20	1.355	0.4756
10	0.745	0.4597	21	1.427	0.4778
11	0.807	0.4611			

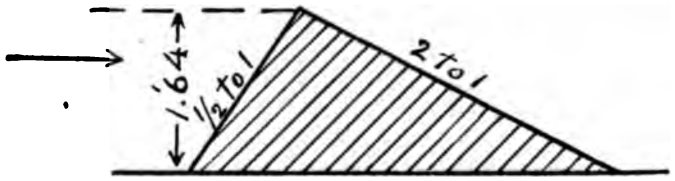
BAZIN'S SERIES NO. 139.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.190	0.4561	12	0.852	0.4789
2	0.253	0.4585	13	0.915	0.4808
3	0.312	0.4641	14	0.969	0.4821
4	0.375	0.4570	15	1.023	0.4883
5	0.434	0.4651	16	1.092	0.4856
6	0.500	0.4643	17	1.151	0.4868
7	0.552	0.4706	18	1.210	0.4909
8	0.615	0.4693	19	1.258	0.4927
9	0.667	0.4764	20	1.326	0.4904
10	0.733	0.4725	21	1.394	0.4898
11	0.798	0.4734			

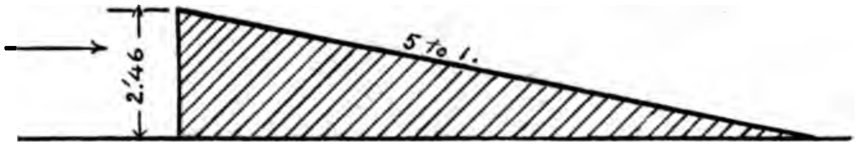
SECOND GROUP.—*Face of the weir, on the upstream side, vertical ar nearly vertical*—**Continued.**

BAZIN'S SERIES NO. 140.



Number of experiment. (1)	h=depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth of crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.191	0.4696	12	0.837	0.4843
2	0.252	0.4666	13	0.905	0.4889
3	0.308	0.4677	14	0.961	0.4861
4	0.371	0.4620	15	1.023	0.4920
5	0.436	0.4699	16	1.080	0.4905
6	0.487	0.4666	17	1.143	0.4951
7	0.549	0.4747	18	1.195	0.4930
8	0.604	0.4761	19	1.254	0.4951
9	0.664	0.4783	20	1.316	0.4978
10	0.719	0.4792	21	1.375	0.5000
11	0.785	0.4842			

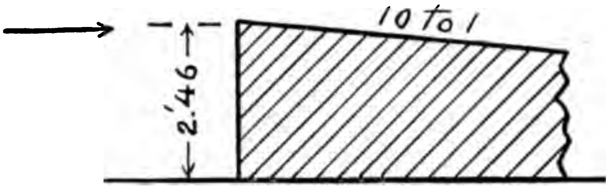
BAZIN'S SERIES NO. 141.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.214	0.3771	11	0.888	0.3960
2	0.281	0.3854	12	0.956	0.3977
3	0.355	0.3831	13	1.029	0.3978
4	0.425	0.3790	14	1.113	0.3955
5	0.489	0.3836	15	1.165	0.3996
6	0.561	0.3846	16	1.237	0.3987
7	0.624	0.3957	17	1.298	0.4016
8	0.692	0.3882	18	1.369	0.4016
9	0.758	0.3901	19	1.431	0.4047
10	0.822	0.3933	20	1.463	0.4051

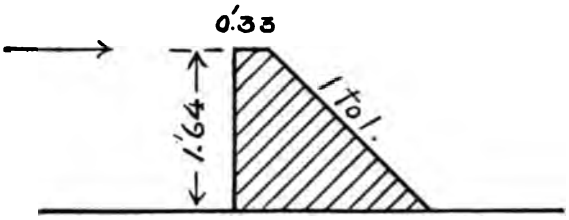
SECOND GROUP.—*Face of the weir, on the upstream side, vertical or nearly vertical*—Continued.

BAZIN'S SERIES NO. 142.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.300	0.3537	10	0.934	0.3681
2	0.369	0.3624	11	1.007	0.3677
3	0.447	0.3582	12	1.079	0.3710
4	0.500	0.3565	13	1.149	0.3716
5	0.591	0.3594	14	1.222	0.3726
6	0.666	0.3572	15	1.285	0.3738
7	0.727	0.3639	16	1.362	0.3742
8	0.795	0.3660	17	1.430	0.3752
9	0.861	0.3661			

BAZIN'S SERIES NO. 143.

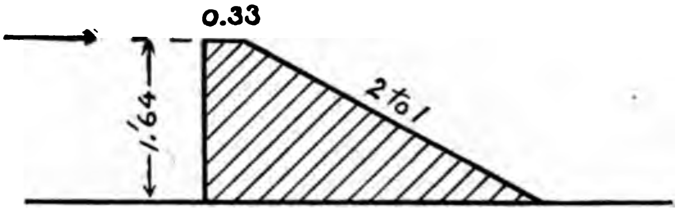


Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.352	*a* 0.3886	11	0.874	0.5135
2	0.415	0.3985	12	0.920	0.5208
3	0.462	0.4250	13	0.972	0.5283
4	0.513	0.4386	14	1.022	0.5321
5	0.567	0.4515	15	1.072	0.5404
6	0.619	0.4608	16	1.126	0.5435
7	0.675	0.4704	17	1.172	0.5489
8	0.725	0.4803	18	1.227	0.5514
9	0.771	0.4938	19	1.331	*b* 0.5250
10	0.821	0.5059	20	1.369	0.5229

a Nappe adhering and attached to flat crest.
b Nappe adhering, but detached from flat crest.

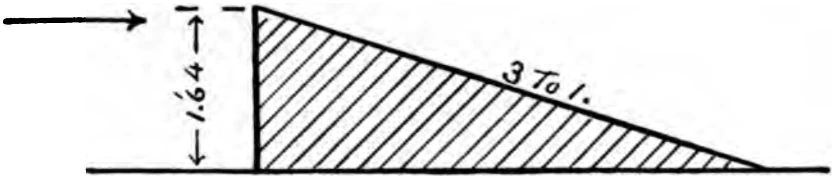
SECOND GROUP.—*Face of the weir, on the upstream side, vertical or nearly vertical*—Continued.

BAZIN'S SERIES NO. 144.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.358	0.3808	11	0.919	0.4714
2	0.419	0.3954	12	0.978	0.4777
3	0.475	0.4081	13	1.034	0.4774
4	0.533	0.4205	14	1.104	0.4759
5	0.592	0.4255	15	1.164	0.4766
6	0.648	0.4372	16	1.232	0.4769
7	0.700	0.4433	17	1.286	0.4784
8	0.757	0.4531	18	1.351	0.4782
9	0.810	0.4588	19	1.411	0.4811
10	0.865	0.4679			

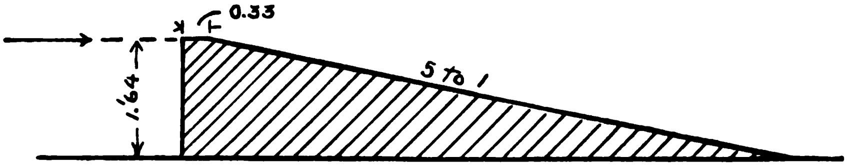
BAZIN'S SERIES NO. 145.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.359	0.3765	11	0.962	0.4409
2	0.424	0.3870	12	1.032	0.4425
3	0.479	0.3971	13	1.087	0.4461
4	0.547	0.4059	14	1.152	0.4474
5	0.598	0.4177	15	1.210	0.4505
6	0.658	0.4218	16	1.274	0.4502
7	0.720	0.4262	17	1.334	0.4515
8	0.781	0.4322	18	1.398	0.4538
9	0.835	0.4358	19	1.467	0.4544
10	0.902	0.4409			

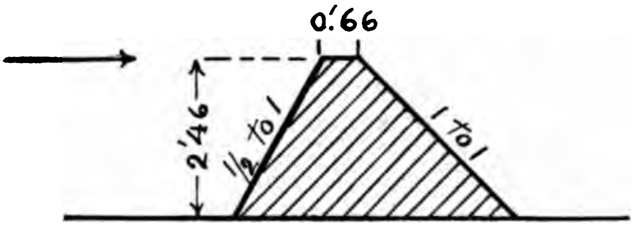
SECOND GROUP.—*Face of the weir, on the upstream side, vertical or nearly vertical*—Continued.

BAZIN'S SERIES NO. 146.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.367	0.3632	11	1.012	0.4080
2	0.437	0.3698	12	1.085	0.4072
3	0.492	0.3837	13	1.141	0.4119
4	0.567	0.3804	14	1.213	0.4124
5	0.621	0.3923	15	1.272	0.4153
6	0.695	0.3885	16	1.344	0.4169
7	0.749	0.3987	17	1.405	0.4190
8	0.817	0.3988	18	1.473	0.4211
9	0.883	0.4021	19	1.532	0.4233
10	0.951	0.4024			

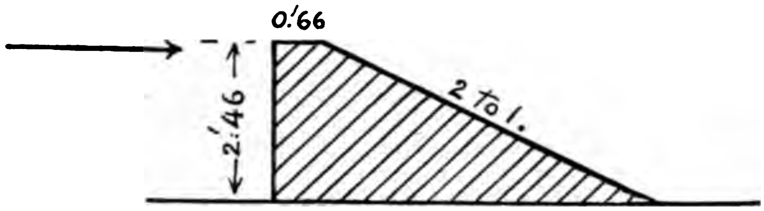
BAZIN'S SERIES NO. 147.



Number of experiment. (1)	h=depth on crest, in feet. (2)	m=coefficient of discharge. (3)	Number of experiment. (1)	h=depth on crest, in feet. (2)	m=coefficient of discharge. (3)
1	0.231	0.3429	12	0.898	0.4409
2	0.308	0.3552	13	0.953	0.4453
3	0.373	0.3566	14	1.015	0.4535
4	0.438	0.3698	15	1.063	0.4580
5	0.503	0.3759	16	1.115	0.4653
6	0.569	0.3907	17	1.165	0.4723
7	0.637	0.3999	18	1.217	0.4775
8	0.681	0.4045	19	1.265	0.4803
9	0.734	0.4170	20	1.332	0.4854
10	0.797	0.4238	21	1.394	0.4962
11	0.845	0.4299			

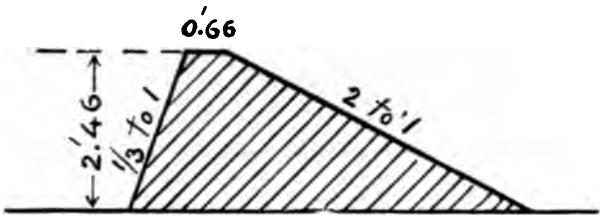
SECOND GROUP.—*Face of the weir, on the upstream side, vertical or nearly vertical*—Continued.

BAZIN'S SERIES NO. 149.



Number of experiment. (1)	*h*=depth on crest, in feet. (2)	*m*=coefficient of discharge. (3)	Number of experiment. (1)	*h*=depth on crest, in feet. (2)	*m*=coefficient of discharge. (3)
1	0.248	0.3158	12	0.942	0.4119
2	0.317	0.3217	13	0.999	0.4193
3	0.390	0.3322	14	1.051	0.4231
4	0.455	0.3410	15	1.103	0.4308
5	0.521	0.3513	16	1.165	0.4353
6	0.585	0.3607	17	1.209	0.4398
7	0.653	0.3705	18	1.281	0.4447
8	0.705	0.3740	19	1.330	0.4492
9	0.768	0.3841	20	1.385	0.4527
10	0.818	0.3946	21	1.446	0.4580
11	0.882	0.4030			

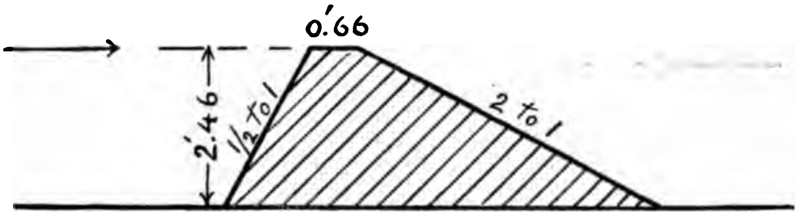
BAZIN'S SERIES NO. 150.



Number of experiment. (1)	*h*=depth on crest, in feet. (2)	*m*=coefficient of discharge. (3)	Number of experiment. (1)	*h*=depth on crest, in feet. (2)	*m*=coefficient of discharge. (3)
1	0.248	0.3153	12	0.928	0.4213
2	0.323	0.3297	13	0.982	0.4261
3	0.379	0.3466	14	1.043	0.4328
4	0.459	0.3515	15	1.095	0.4381
5	0.512	0.3631	16	1.152	0.4430
6	0.586	0.3692	17	1.215	0.4468
7	0.637	0.3832	18	1.259	0.4529
8	0.698	0.3892	19	1.315	0.4553
9	0.751	0.3967	20	1.323	0.4555
10	0.814	0.4063	21	1.380	0.4592
11	0.869	0.4127	22	1.439	0.4645

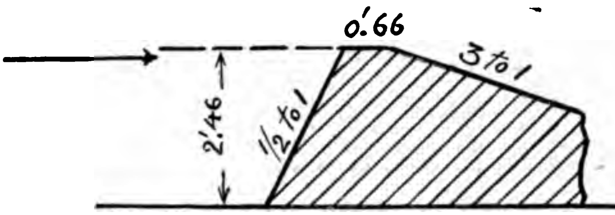
Second Group.—*Face of the weir, on the upstream side, vertical or nearly vertical*—Continued.

BAZIN'S SERIES NO. 151.



Number of experiment. (1)	h=depth on crest, in feet. (2)	m=coefficient of discharge. (3)	Number of experiment. (1)	h=depth on crest, in feet. (2)	m=coefficient of discharge. (3)
1	0.201	0.3373	14	0.867	0.4191
2	0.240	0.3508	15	0.921	0.4226
3	0.307	0.3476	16	0.975	0.4311
4	0.391	0.3473	17	1.027	0.4373
5	0.445	0.3641	18	1.090	0.4395
6	0.514	0.3679	19	1.112	0.4459
7	0.537	0.3720	20	1.140	0.4493
8	0.573	0.3807	21	1.209	0.4499
9	0.643	0.3859	22	1.248	0.4546
10	0.695	0.3990	23	1.314	0.4587
11	0.756	0.4047	24	1.352	0.4629
12	0.800	0.4120	25	1.416	0.4669
13	0.826	0.4131			

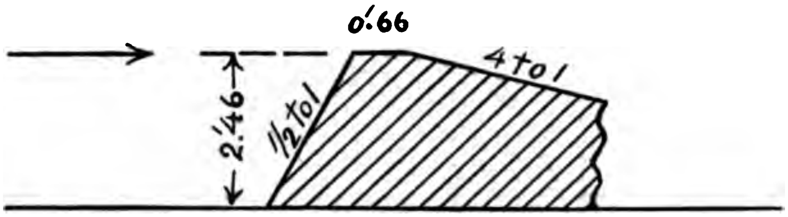
BAZIN'S SERIES NO. 153.



Number of experiment. (1)	h=depth on crest, in feet. (2)	m=coefficient of discharge. (3)	Number of experiment. (1)	h=depth on crest, in feet. (2)	m=coefficient of discharge. (3)
1	0.237	0.3408	14	0.879	0.4057
2	0.301	0.3458	15	0.937	0.4107
3	0.372	0.3476	16	0.993	6.4171
4	0.373	0.3534	17	1.001	0.4159
5	0.440	0.3613	18	1.055	0.4237
6	0.505	0.3649	19	1.102	0.4253
7	0.576	0.3747	20	1.170	0.4318
8	0.637	0.3827	21	1.226	0.4341
9	0.696	0.3866	22	1.290	0.4379
10	0.701	0.3863	23	1.289	0.4392
11	0.760	0.3930	24	1.347	0.4408
12	0.762	0.3940	25	1.404	0.4463
13	0.814	0.3906	26	1.436	0.4466

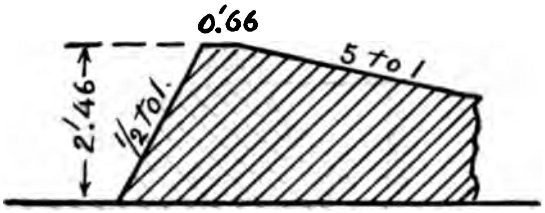
SECOND GROUP.—*Face of the weir, on the upstream side, vertical or nearly vertical*—Continued.

BAZIN'S SERIES NO. 154.



Number of experiment. (1)	*h*=depth on crest, in feet. (2)	*m*=coefficient of discharge. (3)	Number of experiment. (1)	*h*=depth on crest, in feet. (2)	*m*=coefficient of discharge. (3)
1	0.236	0.3370	11	0.888	0.3995
2	0.308	0.3421	12	0.946	0.4043
3	0.373	0.3521	13	1.011	0.4095
4	0.447	0.3554	14	1.075	0.4123
5	0.508	0.3677	15	1.138	0.4186
6	0.577	0.3701	16	1.195	0.4204
7	0.643	0.3787	17	1.250	0.4245
8	0.706	0.3826	18	1.310	0.4282
9	0.760	0.3950	19	1.370	0.4298
10	0.823	0 3987	20	1.430	0.4334

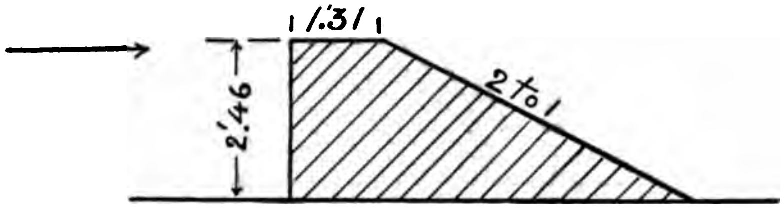
BAZIN'S SERIES NO. 156.



Number of experiment. (1)	*h*=depth on crest, in feet. (2)	*m*=coefficient of discharge. (3)	Number of experiment. (1)	*h*=depth on crest, in feet. (2)	*m*=coefficient of discharge. (3)
1	0.245	0.3441	11	0.888	0.3958
2	0.311	0.3488	12	0.956	0.4035
3	0.382	0.3544	13	1.018	0.4021
4	0.446	0.3611	14	1.073	0.4119
5	0.508	0.3624	15	1.138	0.4108
6	0.576	0.3675	16	1.203	0.4126
7	0.638	0.3758	17	1.269	0.4161
8	0.703	0.3821	18	1.340	0.4194
9	0.764	0.3860	19	1.394	0.4195
10	0.834	0.3897	20	1.457	0.4227

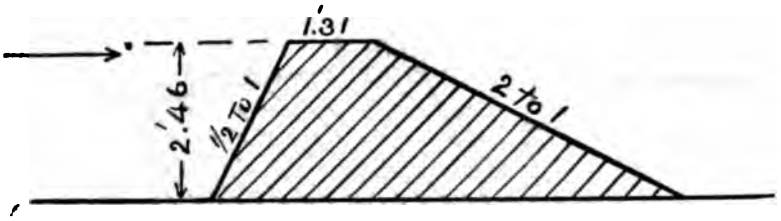
Second Group.—*Face of the weir, on the upstream side, vertical or nearly vertical*—Continued.

BAZIN'S SERIES NO. 157.



Number of experiment. (1)	h=depth on crest, in feet. (2)	m=coefficient of discharge. (3)	Number of experiment. (1)	h=depth on crest, in feet. (2)	m=coefficient of discharge. (3)
1	0.241	0.3282	11	0.957	0.3574
2	0.321	0.3238	12	1.030	0.3591
3	0.395	0.3280	13	1.093	0.3655
4	0.475	0.3299	14	1.156	0.3698
5	0.547	0.3288	15	1.216	0.3765
6	0.624	0.3317	16	1.277	0.3801
7	0.696	0.3371	17	1.337	0.3855
8	0.765	0.3408	18	1.394	0.3883
9	0.828	0.3470	19	1.456	0.3959
10	0.898	0.3498	20	1.474	0.3989

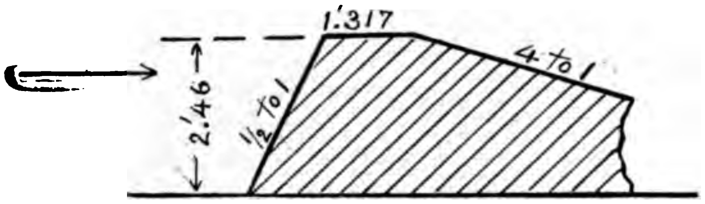
BAZIN'S SERIES NO. 158.



Number of experiment. (1)	h=depth on crest, in feet. (2)	m=coefficient of discharge. (3)	Number of experiment. (1)	h=depth on crest, in feet. (2)	m=coefficient of discharge. (3)
1	0.234	0.3470	11	0.930	0.3744
2	0.312	0.3389	12	0.984	0.3799
3	0.383	0.3463	13	1.055	0.3866
4	0.457	0.3479	14	1.125	0.3889
5	0.530	0.3490	15	1.179	0.3923
6	0.600	0.3524	16	1.243	0.3983
7	0.672	0.3559	17	1.297	0.4025
8	0.733	0.3606	18	1.361	0.4066
9	0.799	0.3633	19	1.412	0.4112
10	0.860	0.3682	20	1.457	0.4142

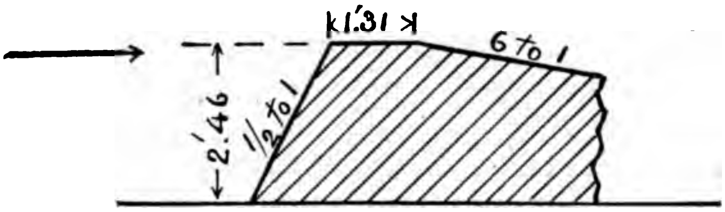
Second Group.—*Face of the weir, on the upstream side, vertical or nearly vertical*—Continued.

BAZIN'S SERIES NO. 159.



Number of experiment. (1)	h=depth on crest, in feet. (2)	m=coefficient of discharge. (3)	Number of experiment. (1)	h=depth on crest, in feet. (2)	m=coefficient of discharge. (3)
1	0.234	0.3333	14	0.876	0.3665
2	0.304	0.3424	15	0.935	0.3654
3	0.379	0.3515	16	0.994	0.3751
4	0.387	0.3507	17	1.068	0.3777
5	0.457	0.3498	18	1.128	0.3800
6	0.516	0.3620	19	1.145	0.3798
7	0.526	0.3544	20	1.198	0.3839
8	0.599	0.3519	21	1.261	0.3878
9	0.664	0.3571	22	1.320	0.3935
10	0.670	0.3527	23	1.332	0.3906
11	0.735	0.3591	24	1.389	0.3912
12	0.797	0.3662	25	1.445	0.3978
13	0.861	0.3727	26	1.456	0.3977

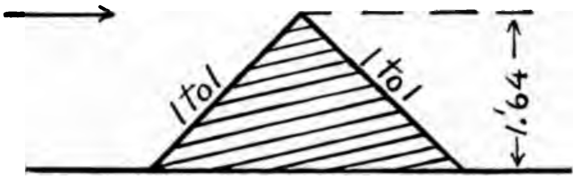
BAZIN'S SERIES NO. 160.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.451	0.3505	9	0.998	0.3731
2	0.522	0.3512	10	1.074	0.3772
3	0.593	0.3541	11	1.129	0.3784
4	0.663	0.3589	12	1.193	0.3818
5	0.735	0.3598	13	1.254	0.3842
6	0.798	0.3629	14	1.326	0.3868
7	0.863	0.3641	15	1.389	0.3919
8	0.930	0.3701	16	1.457	0.3937

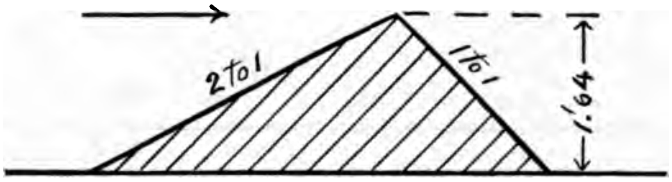
THIRD GROUP.—*Slope of weir face both above and below, in neither case exceeding 45° from the horizontal.*

BAZIN'S SERIES NO. 161.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.298	0.5373	14	0.992	0.5359
2	0.354	0.5357	15	1.019	0.5374
3	0.413	0.5308	16	1.056	0.5340
4	0.472	0.5272	17	1.083	0.5323
5	0.529	0.5259	18	1.118	0.5282
6	0.581	0.5297	19	1.157	0.5196
7	0.639	0.5289	20	1.187	0.5188
8	0.693	0.5314	21	1.225	0.5139
9	0.750	0.5331	22	1.263	0.5102
10	0.803	0.5374	23	1.289	0.5118
11	0.864	0.5373	24	1.328	0.5087
12	0.919	0.5385	25	1.359	0.5086
13	0.960	0.5405			

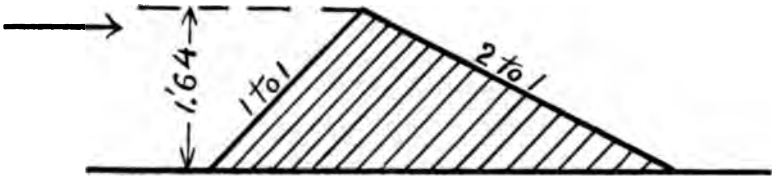
BAZIN'S SERIES NO. 162.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.302	0.5262	11	0.866	0.5310
2	0.360	0.5254	12	0.923	0.5306
3	0.413	0.5257	13	0.982	0.5305
4	0.472	0.5228	14	1.037	0.5301
5	0.529	0.5246	15	1.099	0.5287
6	0.586	0.5250	16	1.163	0.5241
7	0.644	0.5233	17	1.235	0.5187
8	0.697	0.5228	18	1.297	0.5164
9	0.755	0.5253	19	1.350	0.5137
10	0.810	0.5280			

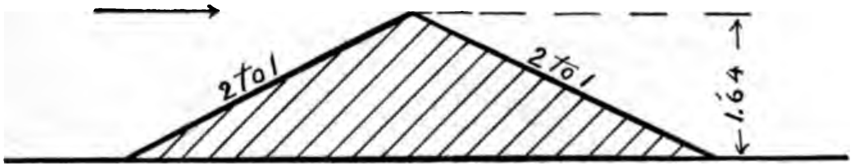
Third Group.—*Slope of weir face both above and below, in neither case exceeding 45° from the horizontal*—**Continued.**

BAZIN'S SERIES NO. 163.



Number of experiment. (1)	h=depth on crest, in feet. (2)	m=coefficient of discharge. (3)	Number of experiment. (1)	h=depth on crest, in feet. (2)	m=coefficient of discharge. (3)
1	0.184	0.4746	12	0.827	0.5017
2	0.244	0.4781	13	0.882	0.5006
3	0.303	0.4786	14	0.949	0.5038
4	0.366	0.4775	15	0.998	0.5062
5	0.423	0.4779	16	1.056	0.5060
6	0.486	0.4759	17	1.114	0.5052
7	0.536	0.4816	18	1.171	0.5071
8	0.593	0.4917	19	1.231	0.5076
9	0.653	0.4880	20	1.285	0.5129
10	0.702	0.4993	21	1.339	0.5199
11	0.769	0.4966			

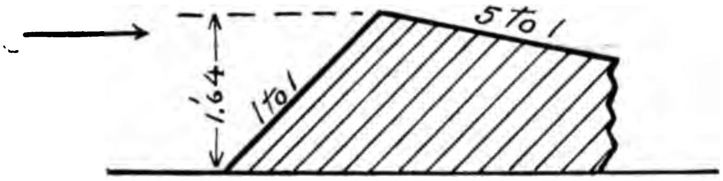
BAZIN'S SERIES NO. 164.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.244	0.4811	11	0.817	0.5021
2	0.305	0.4861	12	0.877	0.5046
3	0.367	0.4821	13	0.939	0.5070
4	0.425	0.4867	14	0.993	0.5111
5	0.482	0.4828	15	1.052	0.5093
6	0.539	0.4826	16	1.115	0.5138
7	0.592	0.4913	17	1.162	0.5151
8	0.651	0.4915	18	1.219	0.5172
9	0.702	0.4948	19	1.277	0.5205
10	0.766	0.4990	20	1.330	0.5217

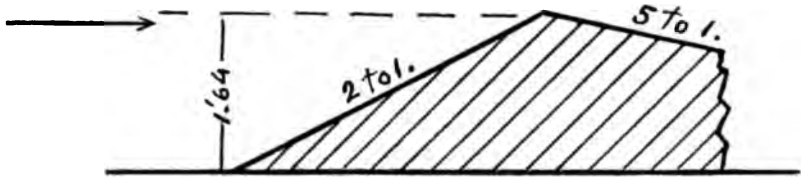
Third Group.—*Slope of weir face both above and below, in neither case exceeding 45° from the horizontal*—Continued.

BAZIN'S SERIES NO. 165.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.337	0.4435	11	0.969	0.4528
2	0.401	0.4447	12	1.029	0.4531
3	0.464	0.4443	13	1.090	0.4538
4	0.528	0.4433	14	1.153	0.4553
5	0.593	0.4413	15	1.217	0.4563
6	0.656	0.4422	16	1.279	0.4584
7	0.720	0.4422	17	1.341	0.4583
8	0.783	0.4433	18	1.401	0.4601
9	0.843	0.4461	19	1.448	0.4648
10	0.904	0.4506			

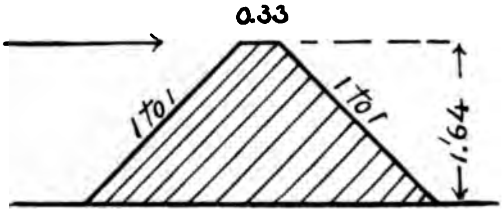
BAZIN'S SERIES, NO. 166.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.330	0.4563	10	0.880	0.4663
2	0.393	0.4548	11	0.947	0.4677
3	0.455	0.4536	12	1.008	0.4681
4	0.518	0.4538	13	1.066	0.4699
5	0.575	0.4579	14	1.127	0.4714
6	0.638	0.4579	15	1.187	0.4723
7	0.699	0.4583	16	1.247	0.4731
8	0.761	0.4596	17	1.308	0.4746
9	0.821	0.4625	18	1.372	0.4748

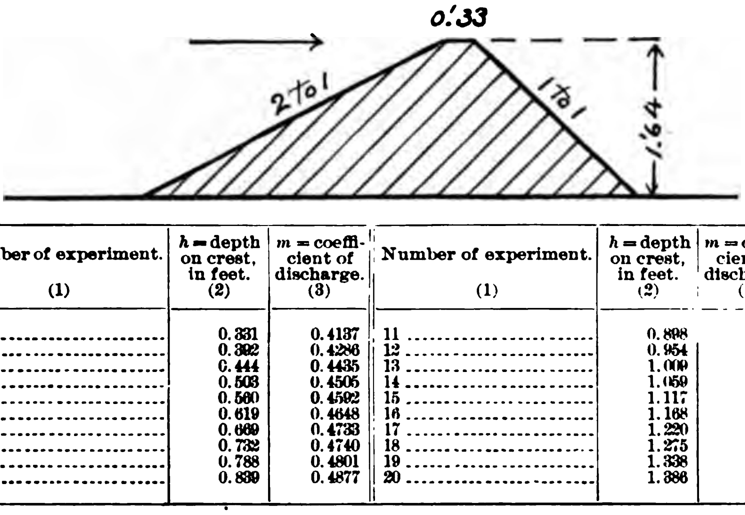
THIRD GROUP.—*Slope of weir face both above aud below, in neither case exceeding 45° from the horizontal*—Continued.

BAZIN'S SERIES, NO. 167.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.341	0.4087	11	0.885	0.5046
2	0.398	0.4256	12	0.930	0.5127
3	0.453	0.4367	13	0.987	0.5176
4	0.509	0.4541	14	1.044	0.5213
5	0.565	0.4577	15	1.084	0.5293
6	0.616	0.4679	16	1.142	0.5319
7	0.671	0.4753	17	1.193	0.5349
8	0.725	0.4823	18	1.245	0.5396
9	0.781	0.4917	19	1.304	0.5431
10	0.828	0.4975	20	1.354	0.5437

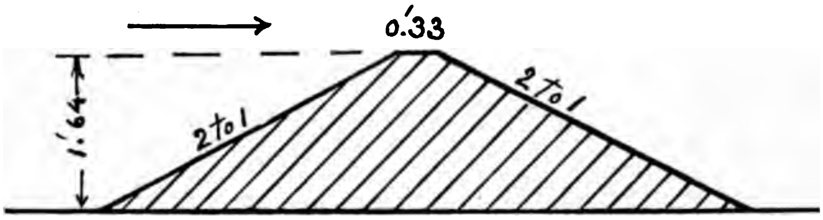
BAZIN'S SERIES, NO. 168.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.331	0.4137	11	0.898	0.4915
2	0.392	0.4286	12	0.954	0.4949
3	0.444	0.4435	13	1.009	0.4999
4	0.503	0.4505	14	1.059	0.5058
5	0.560	0.4592	15	1.117	0.5080
6	0.619	0.4648	16	1.168	0.5122
7	0.669	0.4733	17	1.220	0.5189
8	0.732	0.4740	18	1.275	0.5180
9	0.788	0.4801	19	1.338	0.5205
10	0.839	0.4877	20	1.386	0.5252

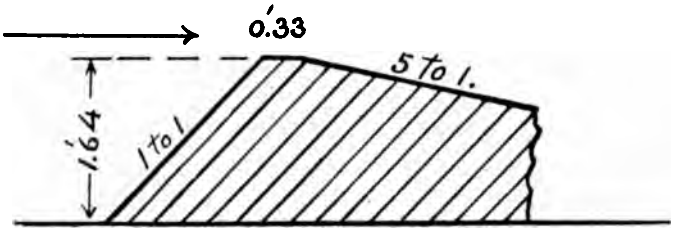
Third Group.—*Slope of weir face both above and below, in neither case exceeding 45° from the horizontal*—**Continued.**

BAZIN'S SERIES, NO. 170.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.351	0.4184	9	0.811	0.4753
2	0.411	0.4300	10	0.871	0.4796
3	0.468	0.4364	11	0.926	0.4824
4	0.529	0.4488	12	0.981	0.4895
5	0.585	0.4488	13	1.009	0.4928
6	0.642	0.4576	14	1.060	0.4948
7	0.701	0.4632	15	1.115	0.4987
8	0.753	0.4689	16	1.174	0.5027

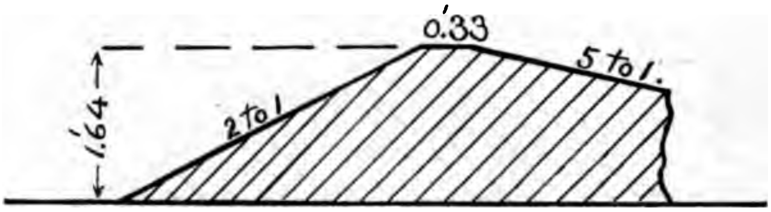
BAZIN'S SERIES, NO. 172.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.356	0.3872	11	0.962	0.4436
2	0.419	0.4025	12	1.026	0.4460
3	0.482	0.4039	13	1.086	0.4482
4	0.539	0.4143	14	1.152	0.4499
5	0.602	0.4175	15	1.204	0.4558
6	0.661	0.4223	16	1.267	0.4586
7	0.722	0.4255	17	1.325	0.4607
8	0.779	0.4333	18	1.377	0.4670
9	0.838	0.4368	19	1.449	0.4645
10	0.906	0.4414			

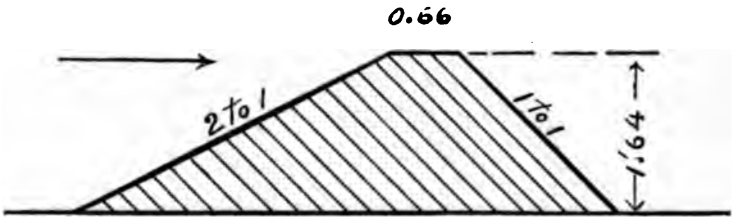
Third Group.—*Slope of weir face both above and below, in neither case exceeding 45° from the horizontal*—**Continued.**

BAZIN'S SERIES, NO. 173.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.346	0.3962	11	0.960	0.4447
2	0.410	0.4030	12	1.021	0.4480
3	0.471	0.4159	13	1.074	0.4532
4	0.532	0.4155	14	1.137	0.4555
5	0.594	0.4223	15	1.198	0.4572
6	0.658	0.4233	16	1.260	0.4610
7	0.714	0.4319	17	1.315	0.4619
8	0.769	0.4363	18	1.375	0.4652
9	0.834	9.4398	19	1.386	0.4642
10	0.892	0.4438			

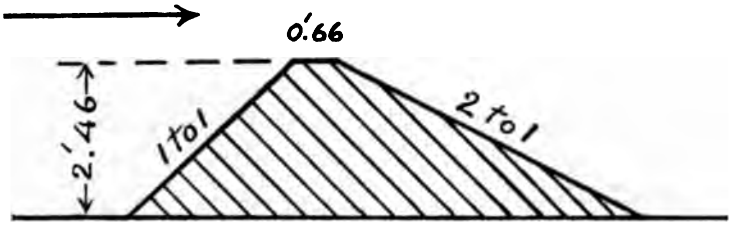
BAZIN'S SERIES, NO. 175.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.360	0.3950	11	0.949	0.4607
2	0.421	0.4061	12	1.007	0.4649
3	0.487	0.4054	13	1.061	0.4710
4	0.548	0.4119	14	1.123	0.4747
5	0.608	0.4220	15	1.174	0.4790
6	0.667	0.4281	16	1.230	0.4811
7	0.728	0.4337	17	1.287	0.4845
8	0.782	0.4396	18	1.347	0.4869
9	0.837	0.4482	19	1.387	0.4908
10	0.894	0.4554			

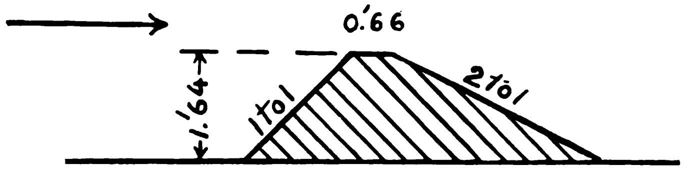
Third Group.—*Slope of weir face both above and below, in neither case exceeding 45° from the horizontal*—**Continued.**

BAZIN'S SERIES, NO. 176.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.237	0.3439	12	0.910	0.4296
2	0.296	0.3413	13	0.974	0.4376
3	0.365	0.3636	14	1.027	0.4409
4	0.439	0.3684	15	1.088	0.4449
5	0.494	0.3795	16	1.139	0.4518
6	0.565	0.3867	17	1.196	0.4547
7	0.618	0.3977	18	1.248	0.4586
8	0.682	0.4021	19	1.303	0.4652
9	0.733	0.4104	20	1.355	0.4676
10	0.797	0.4175	21	1.420	0.4727
11	0.861	0.4251			

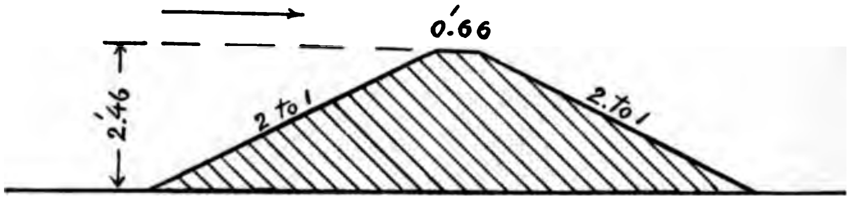
BAZIN'S SERIES NO. 177.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.367	0.3803	11	0.965	0.4562
2	0.433	0.3872	12	1.019	0.4621
3	0.497	0.3993	13	1.077	0.4658
4	0.556	0.4050	14	1.129	0.4716
5	0.617	0.4127	15	1.184	0.4753
6	0.680	0.4180	16	1.243	0.4779
7	0.739	0.4242	17	1.296	0.4840
8	0.794	0.4309	18	1.346	0.4867
9	0.850	0.4389	19	1.386	0.4924
10	0.906	0.4482			

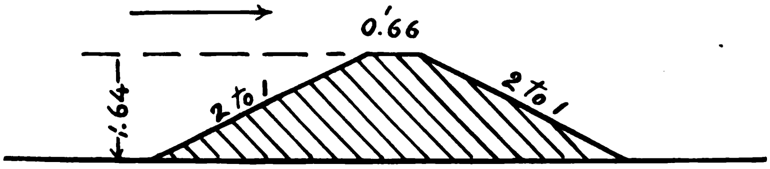
Third Group.—*Slope of weir face both above and below, in neither case exceeding 45° from the horizontal*—Continued.

BAZIN'S SERIES NO. 178.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.222	0.3522	12	0.906	0.4315
2	0.299	0.3673	13	0.966	0.4379
3	0.367	0.3686	14	1.028	0.4398
4	0.431	0.3837	15	1.083	0.4467
5	0.491	0.3907	16	1.142	0.4493
6	0.556	0.3981	17	1.195	0.4540
7	0.614	0.4038	18	1.259	0.4567
8	0.669	0.4093	19	1.314	0.4600
9	0.732	0.4147	20	1.366	0.4633
10	0.789	0.4190	21	1.424	0.4670
11	0.847	0.4271			

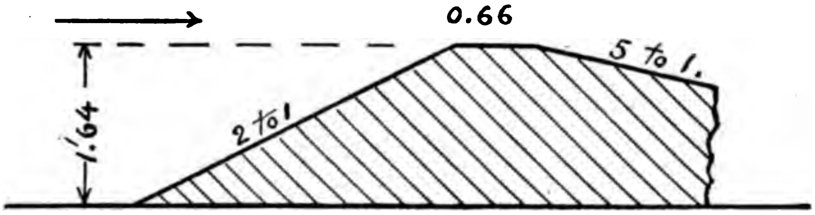
BAZIN'S SERIES NO. 179.



Number of experiment. (1)	h=depth on crest, in feet. (2)	m=coefficient of discharge. (3)	Number of experiment. (1)	h=depth on crest, in feet. (2)	m=coefficient of discharge. (3)
1	0.364	0.3930	11	0.968	0.4536
2	0.431	0.3997	12	1.023	0.4588
3	0.490	0.4054	13	1.078	0.4641
4	0.558	0.4091	14	1.134	0.4655
5	0.614	0.4180	15	1.190	0.4703
6	0.674	0.4244	16	1.247	0.4740
7	0.732	0.4277	17	1.298	0.4796
8	0.790	0.4331	18	1.357	0.4840
9	0.851	0.4399	19	1.403	0.4884
10	0.908	0.4480			

THIRD GROUP.—*Slope of weir face both above and below, in neither case exceeding 45° from the horizontal*—Continued.

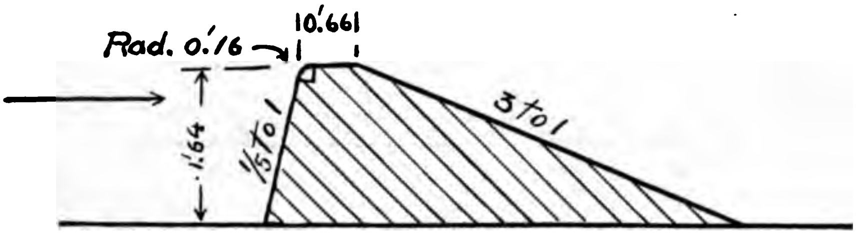
BAZIN'S SERIES NO. 181.



Number of experiment. (1)	h=depth on crest, in feet. (2)	m=coefficient of discharge. (3)	Number of experiment. (1)	h=depth on crest, in feet. (2)	m=coefficient of discharge. (3)
1	0.219	0.3789	12	0.920	0.4267
2	0.290	0.3858	13	0.983	0.4311
3	0.356	0.3863	14	1.044	0.4345
4	0.423	0.3900	15	1.111	0.4394
5	0.486	0.3993	16	1.159	0.4413
6	0.554	0.3970	17	1.228	0.4447
7	0.621	0.4030	18	1.278	0.4484
8	0.677	0.4092	19	1.342	0.4518
9	0.743	0.4105	20	1.403	0.4534
10	0.797	0.4153	21	1.463	0.4578
11	0.861	0.4210			

FOURTH GROUP.—*The two faces of the weir united by a curved surface at the crest.*

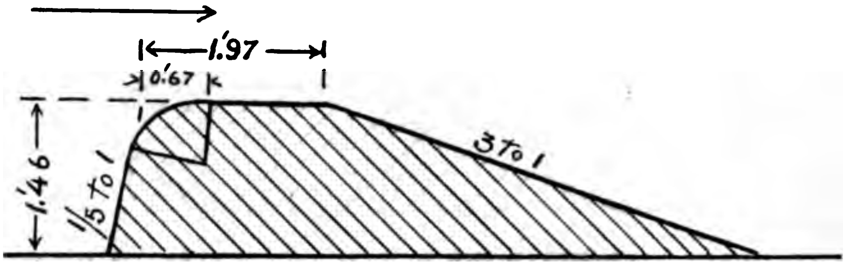
BAZIN'S SERIES NO. 182.



Number of experiment. (1)	h=depth on crest, in feet. (2)	m=coefficient of discharge. (3)	Number of experiment. (1)	h=depth on crest, in feet (2)	m=coefficient of discharge. (3)
1	0.280	0.3927	7	0.989	0.4654
2	0.403	0.4012	8	1.091	0.4749
3	0.526	0.4150	9	1.210	0.4821
4	0.641	0.4309	10	1.320	0.4870
5	0.761	0.4448	11	1.413	0.4966
6	0.867	0.4584			

Fourth Group.—*The two faces of the weir united by a curved surface at the crest*—Continued.

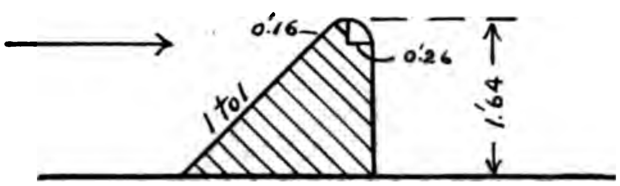
BAZIN'S SERIES NO. 188.



Number of experiment. (1)	h=depth on crest, in feet. (2)	m=coefficient of discharge. (3)	Number of experiment. (1)	h=depth on crest, in feet. (2)	m=coefficient of discharge. (3)
1	0.289	0.3758	7	1.080	0.4120
2	0.425	0.3835	8	1.201	0.4193
3	0.563	0.3836	9	1.322	0.4274
4	0.697	0.3925	10	1.431	0.4388
5	0.825	0.3982	11	1.546	0.4432
6	0.953	0.4045			

Fifth Group.—*Weirs with the profile of the crest completely curved.*

BAZIN'S SERIES NO. 189.

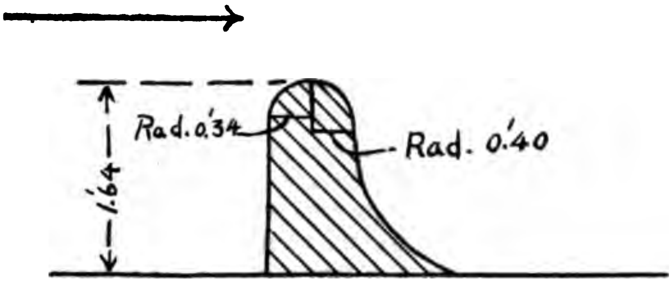


Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (2)
1	0.248	*a* 0.4605	12	0.756	0.5664
2	0.300	0.4834	13	0.811	0.5706
3	0.355	0.4967	14	0.864	0.5698
4	0.406	0.5090	15	0.923	0.5677
5	0.457	0.5198	16	0.979	0.5681
6	0.511	0.5331	17	1.042	0.5644
7	0.557	0.5389	18	1.097	0.5612
8	0.607	0.5517	19	1.151	0.5629
9	0.655	0.5563	20	1.227	0.5550
10	0.706	0.5635	21	1.274	0.5572
11	0.706	*b* 0.5624			

a Adhering nappe. *b* Nappe wetted underneath.

Fifth Group.—*Weirs with the profile of the crest completely covered*—Continued.

BAZIN'S SERIES NO. 193.



Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)	Number of experiment. (1)	h = depth on crest, in feet. (2)	m = coefficient of discharge. (3)
1	0.260	0.4354	11	0.780	0.5418
2	0.317	0.4496	12	0.836	0.5480
3	0.374	0.4635	13	0.886	0.5559
4	0.429	0.4716	14	0.932	0.5628
5	0.478	0.4891	15	0.979	0.5644
6	0.534	0.4924	16	1.035	0.5710
7	0.585	0.5049	17	1.093	0.5675
8	0.634	0.5108	18	1.148	0.5663
9	0.684	0.5238	19	1.201	0.5695
10	0.736	0.5293	20	1.258	0.5665

DATA USED IN WORKING UP ORIGINAL DISCHARGE CURVES ON PLATES 107 TO 126, INCLUSIVE.

On plates 107 to 126, inclusive, we have given a series of discharge curves computed for the several dams at which gaugings have been made. As will be noticed, two curves are shown on most of these plates. The full-line curve is that derived from Bazin's work applied with the best judgment that could be brought to bear upon the subject, while the dotted-line curve represents a new discharge curve, determined as the result of experiments on flows over various weirs made during May and June at the Cornell University Hydraulic Laboratory, and to be described further on. The following embodies a concise statement of the reasoning upon which was based the original full-line discharge curves, as determined from Bazin's experiments and as shown on plates 107 to 126, inclusive, together with brief explanations as to the revised curves shown by dotted lines.

In the chapter on Gauging of Streams Tributary to Deep Waterways in Central and Eastern New York the author has briefly described each gauging station, referring therein to the taking of profiles and cross sections of the crests. In order to apply Bazin's coefficients, the longitudinal profiles of the several crests were plotted at a large scale and each crest divided into a series of approximately level sections, as shown by the longitudinal sections on plates 107 to 126.

It was assumed that at the end of each individual section the conditions of flow would be the same as though the end of the section were the end of a dam without any lateral contraction. In order to apply Bazin's coefficients, curves of flow over a single foot of crest were then plotted, as illustrated by plates 129 and 130, whereon are given discharge curves for a single foot of crest for Bazin's series of experiments Nos. 170 and 175.

At gauging station No. 1 (plate 107) flashboards of 2-inch plank 1 foot in height are used during most of the year for a portion of the crest. When these flashboards are in place the flow over this section of dam has been computed by Francis's weir formula. The situation at this station is somewhat complicated by the presence of the old dam just back of the new dam, as shown on plate 107. Taking into account the water cushion between the two crests, it was considered that Bazin's series No. 115 for a crest 6.56 feet in width would fairly apply. The discharge curve for this station, as given on plate 107, has therefore been computed on this basis. These discharge curves are in every case for full length of dam, and for the stated heads from 0 to 4 feet.

The Cornell University experiments not having furnished any data applying to Baldwinsville dam, the discharge curve has been left as originally drawn.

At gauging station No. 2 (plate 108) the front of the dam is nearly vertical, with back slopes of 8 to 1 and with crest slightly rounded. Bazin's section making nearest approach to this was series No. 117, which was recognized, however, as being only an approximation. Cornell University experiment No. 3 has furnished the data for working out a new discharge curve applying more closely to the conditions of this dam than the original. It is believed that the revised curve gives the true discharge over this dam within a small per cent. At a depth of 2 feet on the crest the discharge by the revised curve is 9.8 per cent less than by the original curve.

At gauging station No. 3 (plate 109) sections A and C on profile of crest are over the tops of frames holding drop boards and having a cross section nearly the same as Bazin's series No. 113. For the main part of the dam series No. 130 has been used.

On referring to elevation of dam on plate 109 it will be seen that at the right-hand side there are several openings in the bulkhead when the drop boards are set down to the level of the crest of the dam. There are about four posts in a distance of 25 feet, and instead of computing the discharge over the thin crest and deducting the posts, the same formula as applied to the regular crest was used and no deduction made for the space occupied by the posts. In very high water the drop boards are taken out.

The revised discharge curve for this dam is based upon Cornell University experiments Nos. 1 and 10. The necessary explanations correlating these data with the original curve may be obtained from pl. 109. The discharge at depth of 2 feet on the crest is 11.9 per cent less than by the original curve.

At gauging station No. 4 (plate 110) the actual cross section corresponds closely to Bazin's series No. 130 or 135. The new curve is based upon Cornell University experiment No. 2. At a depth of 2 feet on the crest the revised curve gives 14.1 per cent less than the original.

At gauging station No. 6 (plate 111) the experimental and actual cross sections are nearly identical, Bazin's series No. 170 best applying. The revised curve gives for 2 feet head on the crest 13.3 per cent less discharge than the original. Cornell University experiment No. 7 has been applied in the revision.

At gauging station No. 7 (plate 112) the experimental and actual sections agree, Bazin's series No. 130 being used. The revised curve is based upon Cornell University experiment No. 1, the discharge at 2 feet head being 13 per cent less than by the original curve.

At gauging station No. 8 (plate 113) there are several sections of the dam requiring to be taken into account. Thus, section A is over a bulkhead next to the sawmill on the right-hand side. Section C is over a portion of the dam with broad, flat crest similar to the bulkhead, while D is a flat-crested section connected with a series of drops for a fishway. B is the spillway of the dam proper and has a section somewhat similar to Bazin's series No. 130. The revised curve is based upon Cornell University experiments Nos. 12 and 16. Variation from original curve at 2 feet depth on crest is 10 per cent.

At gauging station No. 9 (plate 114) the experimental and actual cross sections are almost alike. A recomputation of flow at this station on the basis of the Cornell University experiments shows an immaterial correction. The revised curve varies at 2 feet depth on crest 1.5 per cent from the original.

At gauging station No. 10 (plate 115) the actual section of main part of dam agrees closely with Bazin's series No. 130. The high-water discharge over the bulkheads was computed from Bazin's series No. 115. The revised curve is based upon Cornell University experiments Nos. 1 and 12. The variation at 2 feet depth on crest is 11.7 per cent.

At gauging station No. 11 (plate 116) the crest is flat, as shown, with a flat apron in front. Bazin's series Nos. 117 and 141 were the nearest of any. The Cornell University experiments have modified the curve for this dam very immaterially, as shown. The discharge at 2 feet depth on crest is increased 1.7 per cent over the original.

At gauging station No. 12 (plate 117) the actual section agrees closely with Bazin's series No. 170, which was used. As this station was discontinued in March, 1899, no revision of discharge has been made.

At gauging station No. 13 (plate 118) Bazin's series No. 175 applied more nearly than any other.

Inasmuch as the Cornell University experiments did not include any section applying to this station, no revision of discharge curve has been made. Bazin's series No. 175 is taken to cover the case of the low flows here better than any other.

At gauging station No. 14 (plate 119) Bazin's series No. 170 was used. The revised curve is based upon Cornell University experiment No. 15, on the Rexford Flats dam with rounded corner. At 2 feet depth on crest the revised curve shows 23 per cent less discharge than on the original.

At gauging station No. 15 (plate 120) the dam has a variable section a portion of it being filled with paving behind, as shown for section at A, the balance of the dam being as per section at B on plate 120. The sections of this dam were experimented on at Cornell University and a new discharge curve computed, as shown. The new discharge curve gives 8.8 per cent less flow at 2 feet depth on the crest than the original.

At gauging station No. 16 (plate 121) the crest of the dam is 6 feet wide with a slope to the back of 1 foot. The back of the dam, about 17 feet in height, is vertical. Bazin's series No. 117 was taken as best applying.

There should have been an experiment at Cornell University covering crests and rollerways of the form of this dam. In the absence of such, the revised curve has been based upon Cornell University experiment No. 13. The variation in the two curves is 6 per cent at 2 feet depth on crest.

At gauging station No. 17 (plate 122) Bazin's series No. 130 agrees closely with the actual section of dam. The revised discharge curve is based upon Cornell University experiment No. 1. The variation in the discharge at 2 feet depth on the crest is 9.3 per cent.

At gauging station No. 18 (plate 123) none of Bazin's experiments absolutely apply. Series No. 130 is taken as closer than any other to the main part of the dam, while the flow over the bulkheads at the sides is computed from series No. 115. The revised discharge curve is based upon Cornell University experiments Nos. 2 and 12. The variation at 2 feet depth on crest is 14 per cent.

At gauging station No. 19 (plate 124) the dam is, as shown, very flat, with a flat apron in front. Bazin's series No. 117 and No. 197 were taken as best applying. A recomputation of discharge curve, using the Cornell University data for Rexford Flats section, substantially verifies the curve adopted, as shown. The variation in the two discharge curves below 2 feet depth on crest is practically nothing. Above 2 feet there is a slight increase.

At gauging station No. 20 (plate 125) the conditions are very similar to those at station No. 19. The filling at the back of the dam makes, in effect, a long, flat crest on the upstream side with a flat apron below. Bazin's series No. 117 and No. 141 were taken as best applying. This section was experimented upon at Cornell University, with the result of substantially verifying the original computation. The variation in discharge curves at 2 feet depth is about 1 per cent.

At gauging station No. 24 (plate 126) the actual section of the main part of the dam corresponds closely to Bazin's series No. 135. There is a platform at an angle in the dam to which Bazin's series No. 115 was considered to fairly apply. The revised discharge curve is based upon Cornell University experiments Nos. 2 and 12. At heads of 2 feet on the crest the discharge is diminished 7 per cent, at 4 feet it is diminished 13.2 per cent, and at 6 feet 13.6 per cent.

As shown in the foregoing, the result of the Cornell University experiments was to show that the discharges, as per Bazin's series No. 130 and No. 135, are much too high for the high heads necessary to be used at these several gauging stations, and accordingly all of the discharge curves into which series Nos. 130 and 135 enter materially are considerably reduced. The correction is only small for low heads, but in some cases for high heads it becomes very material. Particularly is this true at station No. 14.

In order to illustrate the method of computation used for obtaining the flow over the various dams we may refer to Schoharie Creek dam, as shown on plate 124. Table No. 12A shows the method of computing discharge curve for this dam, the coefficients used in that table being derived from Cornell University experiment No. 14. In the first place the zero of the crest gauge is at elevation 90.68 feet. The crest itself divides into a series of sections, with elevations reading from the left hand toward the right hand on the profile (plate 124), as follows: For a length of 61.4 feet the mean elevation is 91.02 feet; for a length of 25 feet the mean elevation is 90.64 feet; for a length of 75 feet the mean elevation is 90.77 feet; for a length of 250 feet the mean elevation is 90.90 feet; for a length of 155 feet the mean elevation is 90.82 feet; and for a length of 20 feet the mean elevation is 91.01 feet. The average elevation of each section of the dam having been obtained with reference to the elevation of the zero of the crest gauge, the depth of water flowing over each section corresponding to a series of given heads or readings on the crest gauge was deduced and shown in the first line of Table No. 19 relating to each section. Thus for section A we have, in column (4), the head on section A in feet, and so on for sections B, C, D, E, and F. Following this for each section in column (4), the discharge per foot of crest for various heads extending from 0.2 foot to 8 feet is given. The third line of each division, A, B, C, etc., gives total flow over section for the various heads up to 8 feet. The summation, as given at the bottom of the table, represents the total flow over this dam in cubic feet per second from 0.2 foot up to 8 feet, the range being from 26 cubic feet per second to 40,783 cubic feet per second. The discharge curve on plate 124 has been derived by plotting the final footings of Table No. 12A with heads on crest in feet as ordinates and discharge in cubic feet per second as abscissas.

Table No. 12A illustrates the method used in computing all the discharge curves, plates 107 to 126, inclusive.

By way of illustrating the great variations of discharge over several of Bazin's weirs, which are especially applicable to our gauging stations, plate 128 has been prepared, whereon are given discharge curves for Francis's formula in comparison with Bazin's series Nos. 117, 130, 135, 162, 170, and 173, together with a table showing the discharges per lineal foot of crest as per Bazin for these several weirs.

On plates 107 to 126, inclusive, we have given discharge curves for each gauging station for heads on the crest, in feet, from 0 up to 4 feet.

Table No. 12 A.—*Showing method of computing discharge curve for dam on Schoharie Creek, at Fort Hunter, N. Y.*

[Discharge coefficients are from Cornell University experiment No. 14.]

(1) Section.	(2) Length.	(3) Elevation.	(4) Head above gauge zero	(5) 0.2.	(6) 0.6.	(7) 1.0.	(8) 2.0.	(9) 3.0.	(10) 4.0.	(11) 5.0.	(12) 6.0.	(13) 7.0.	(14) 8.0.
	Feet.	*Feet.*											
A	20	91.01	Head on Section A (feet)		0.27	0.67	1.67	2.67	3.67	4.67	5.67	6.67	7.67
			Discharge per foot of crest		0.37	1.62	0.82	14.13	22.73	32.62	43.62	55.80	68.30
			Total flow over section		7.4	32.4	136	283	455	652	872	1,116	1,366
B	155	90.82	Head on Section B (feet)	0.06	0.46	0.86	1.86	2.86	3.86	4.86	5.86	6.86	7.86
			Discharge per foot of crest	0.06	0.90	2.40	8.20	15.70	24.65	34.65	45.90	58.00	70.85
			Total flow over section	9.3	139.5	372	1,271	2,434	3,821	5,371	7,115	8,990	10,982
C	250	90.90	Head on Section C (feet)		0.38	0.78	1.78	2.78	3.78	4.78	5.78	6.78	7.78
			Discharge per foot of crest		0.70	2.15	7.60	15.10	23.90	33.95	45.00	57.05	69.80
			Total flow over section		175	538	1,900	3,775	5,975	8,488	11,250	14,263	17,450
D	75	90.77	Head on Section D (feet)	0.11	0.51	0.91	1.91	2.91	3.91	4.91	5.91	6.91	7.91
			Discharge per foot of crest	0.10	1.1	2.62	8.46	16.20	25.05	35.20	46.50	58.50	71.50
			Total flow over section	7.5	83	196	634	1,215	1,879	2,640	3,488	4,388	5,363
E	25	90.64	Head on Section E (feet)	0.24	0.64	1.04	2.04	3.04	4.04	5.04	6.04	7.04	8.04
			Discharge per foot of crest	0.36	1.77	3.28	9.40	17.20	26.40	36.60	48.05	60.30	73.30
			Total flow over section	9	44	82	235	430	660	915	1,201	1,508	1,833
F	61.4	91.02	Head on Section F (feet)		0.26	0.66	1.66	2.66	3.66	4.66	5.66	6.66	7.66
			Discharge per foot of crest		0.36	1.60	6.80	14.10	22.70	32.58	43.58	55.75	68.20
			Total flow over section		22.0	98	417	865	1,394	2,000	2,676	3,423	4,187
Total flow over dam in cubic feet per second				26	471	1,318	4,593	9,002	14,184	20,066	26,602	33,688	41,182

Note.—Elevation of zero of crest gauge=90.68 feet.

DESCRIPTION OF BAZIN'S EXPERIMENTS ON WEIRS OF IRREGULAR CROSS SECTION.

The following chapter has been translated from Bazin's paper in Annales des Ponts et Chaussées for 1898.

We will now consider weirs in which the back and front faces, instead of being vertical, have a batter of greater or less inclination. The conditions of discharge will be found to be greatly modified. The batter on the upstream side tends to diminish the contraction in passing over the crest and hence to increase the discharge. The influence of the downstream batter, on the other hand, is not always constant, but varies according to the degree of inclination. If the downstream face is not far from vertical, the nappe adheres to it for small discharges, but becomes detached at a certain head and then follows the condition described as wetted underneath, analogous to that which we have studied for square-timber weirs.[1] If, on the contrary, the batter is nearly horizontal, the nappe does not detach itself, but remains in contact with the face of the weir under all heads. The discharge may, however, vary greatly, according to the degree of inclination of the face. On the other hand, the influence of the width of the crest is considerable, as we have seen in the case of weirs formed of square timbers.[1] Hence a weir with a wide crest and inclined faces may present a large variety of results, each type having, so to speak, its own special scale of coefficients. Such a study to be complete must include a very considerable number of particular cases. Without embracing all possible cases, the experiments have been somewhat numerous. They include weirs with different degrees of batter on the front and back faces and having sharp crests, on the one hand, and on the other, crests 0.10, 0.20, and 0.40 meter in width (0.328, 0.656, and 1.312 feet, respectively).

Some additional experiments have been made on weirs having crests joined to the inclined faces by curved surfaces, and finally weirs have been experimented upon having completely curved profiles.

We may divide the numerous series of experiments into five groups, namely:

(1) Weirs so nearly vertical on the downstream side that the nappe remains detached.

(2) Weirs having the upstream face vertical, or nearly vertical, but with a batter on the downstream face so nearly horizontal that the water always remains in contact.

(3) Weirs both faces of which are at an inclination differing from the horizontal by less than 45°.

(4) Weirs in which the crest is joined to the inclined faces by curved surfaces.

(5) Weirs having completely curved profiles.

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[1] See the preceding articles in this series.

We have indicated, as in the case of inclined sharp-crested weirs, the degree of batter by a fraction such as 3/2, in which the numerator represents the vertical height corresponding to the width of base indicated by the denominator. The fraction 3/2 thus indicates a batter having a vertical rise of 3 and a horizontal run of 2, that is to say, 3/2 equals the tangent of the angle between the plane of the base and the horizontal.

FIRST GROUP.—WEIRS HAVING THE DOWNSTREAM FACE VERTICAL, OR NEARLY VERTICAL.

This group includes ten series of experiments, the results of which differ notably according to the inclination of the batter and the width of the crest. The values of the coefficient $\left(\frac{m}{m'}\right)$, which have been obtained for sharp-crested weirs have been compared with those corresponding to nappes wetted underneath with sharp-crested weirs. Similarly we may conveniently compare the values obtained for weirs with crests 0.10 and 0.20 meter wide (0.328 and 0.656 feet, respectively) to those for flat-crested beam weirs of the same width in the accompanying table No. 13.[1] The coefficients have been made to follow a uniform law by plotting the immediate results of the experiments in such a manner that the head h represents the abscissa and the ratio $\left(\frac{m}{m'}\right)$ the ordinate of a point representing one of the experiments.

A mean curve has been drawn by the aid of these points, and from this curve, drawn on a large scale, values of the ratio $\left(\frac{m}{m'}\right)$ have been taken, corresponding, roundly, to abscissas of 0.10 meter, 0.15 meter, etc. (0.328 foot, 0.656 foot, etc.). All the experiments terminate with nappes wetted underneath; but the discharge for these, as well as for depressed and adhering nappes, is shown in the table, the nature of the nappe in each case being indicated in the proper column. If we consider, first, sharp-crested weirs, we perceive that the appearance of the wetted nappe is preceded by the depressed nappe, imprisoning air between its under surface and the body of the weir, excepting in the case of a weir with a face batter of 3/2, which permits the formation of an adhering nappe. When once the wetted nappe is established, its coefficient does not differ greatly from that for a sharp-crested weir, excepting in the cases where the batter on the back is 3/1 and 3/2, when it is greater. For weirs with flat crests 0.10 meter (0.328 foot) wide the adhering form of nappe appears when the upstream face has a batter of 3/1 or 3/2. The ratio $\left(\frac{m}{m'}\right)$ is also modified, however, by adherence of the water to the flat crest. At the moment when this adhesion ceases the coefficient diminishes suddenly about

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[1] See p. 159. Annales des Ponts et Chaussées. 2d Trimestre. 1898.

10 per cent. This has taken place in the two series Nos. 133 and 134, where the upstream face is vertical. In the other series the head has not been sufficiently large to detach the nappe, and the coefficient remains, in these experiments, greater in value than it would be for a beam weir, in which the nappe has become detached before the given head is attained.

Only one series of experiments has been made on weirs with crest 0.20 meter (0.656 foot) wide, the downstream face being vertical and that on the upstream side having a batter of 1/2. In accordance with the increased width of crest, the wetted nappe does not appear until quite late and with a coefficient notably diminished. It is clear that more extended experiments would have led in all cases to results differing in a similar manner from those for crests 0.10 meter in width. Without going further we may say that on a weir having the downstream face nearly vertical the wetted form of nappe always appears when a certain head has been attained. This limiting head varies with the inclination of the front and back faces and is never the same as that which corresponds to detachment of the nappe from the flat crest, which also influences the value of the coefficient. Each type of weir requires a special study, and in view of the complexity of the conditions involved it is impossible to establish a general formula for the discharge coefficient

SECOND GROUP—FACE OF THE WEIR ON THE UPSTREAM SIDE VERTICAL OR NEARLY VERTICAL.

Considering now the case where, in contradistinction to the first group, the back is nearly vertical and the downstream face has a considerable batter, Table No. 14 shows how the values of $\left(\frac{m}{m'}\right)$ vary from those of series Nos. 125 to 135 in the 25 series of experiments performed for heads of 0.10, 0.15, 0.20 meter, etc. (0.328, 0.492, 0.656 foot, etc.). For sharp-crested weirs with the upstream face vertical the ratio $\left(\frac{m}{m'}\right)$ is nearly constant for each series, the mean values being 1.13, 1.03, 0.90, and 0.84 for batters on the downstream of 1/1, 1/2, 1/5, and 1/10, respectively.

Where the upstream face has a batter of 3/1 or 2/1, it produces, as we have already seen, an increase in the value of the coefficient of a few per cent. Turning to the experiments on weirs with crests 0.10, 0.20, and 0.40 meter (0.328, 0.656, and 1.312 foot, respectively) in width, it may be seen that the coefficients increase with the head, series No. 143 only showing, for the final values, a rapid diminution, proving that the nappe has become detached. It is necessary, in fact, in order that the nappe shall become detached, that the head shall be greater in proportion as the width of the crest becomes greater and the slope of the downstream face more gentle. This limit has not, in general, been reached in the experiments, and the nappes remain attached to the crests, excepting for series No. 143 (batter on the downstream side 1/1), where the detachment of the nappe leads to a diminution of the coefficient ratio from 1.21 to 1.14. The next series, No. 144, indicates also a slight tendency for the ratio $\left(\frac{m}{m'}\right)$ to decrease, the batter here being 1/2. This tendency entirely disappears where the slope of the downstream face is not greater than 1/3 or 1/4. Omitting the results for the relatively small heads of 0.10 meter (0.328 foot) or less, where there are some irregularities, the increments of the coefficient ratio $\left(\frac{m}{m'}\right)$ for heads from 0.10 meter (0.328 foot) to the limits of the experiments are given below for each series, in comparison with the results for a weir with a crest 0.10 meter in width (0.328 foot), series Nos. 133 and 134, and with those for flat-crested weirs, 0.40 meter (1.312 feet) and 2 meters (6.56 feet) in width, series Nos. 113 and 115. The comparison made in this table shows, (1) that for the same width of crest $\left(\frac{m}{m'}\right)$ diminishes when the inclination of the downstream face is gradually diminished below 45°; (2) that, other things being equal—that is to say, for the same batters on the two faces in each case—the ratio $\left(\frac{m}{m'}\right)$ diminishes when the width of the crest is increased. Table No. 15 gives a résumé of this group.

THIRD GROUP—BATTER ON THE UPSTREAM AND DOWNSTREAM FACES VERY GENTLE, NOT EXCEEDING 45°.

Weirs encountered in practice do not often have nearly vertical faces like those we have been considering, but have slopes inclined 45° or more from the vertical. Such weirs have been made the subject of the following experiments, in which slopes of 1/1 and 1/2 on the upstream side have been combined with slopes of 1/1, 1/2, and 1/5 on the downstream side for three different widths of crest. Tables Nos. 16 and 17 give a résumé, in a succinct form, of the general trend of the values of the ratio $\left(\frac{m}{m'}\right)$ in the different series. Each case in the three tables corresponds to one of the six possible combinations of the batters 1/1 and 1/2 on the upstream side, with the inclinations 1/1, 1/2, and 1/5 on the downstream face. The numerical factors given are the values to the nearest 0.005 of the coefficient ratio $\left(\frac{m}{m'}\right)$ for heads of 0.10, 0.20, 0.30, and 0.40 meter (0.328, 0.656, 0.984, and 1.312 foot), respectively. In order that the results given in the tables should be strictly comparable, we have omitted series No. 171 (batter on the downstream face 1/3) and series Nos. 176 and 178, which were executed on a weir 0.75 meter (2.46 feet) in height. The values of $\left(\frac{m}{m'}\right)$ decrease, as usual, when the width of crest is increased, while as regards the inclination of the two faces it is easily seen that the influence of the batter on the downstream side is much the more important.

In most cases the ratio $\left(\frac{m}{m'}\right)$ increases with the head, but in order to investigate more fully the changes in value of $\left(\frac{m}{m'}\right)$ it is necessary to consider separately the case of sharp-crested weirs as distinguished from those with wide crests.

SHARP-CRESTED WEIRS.

Batter 1/1 on downstream side.—The coefficient ratio $\left(\frac{m}{m'}\right)$ decreases as the head h increases from above 1.20 for very slight heads to 1.11 or 1.12 for the largest heads used. Its value is sensibly the same for the two batters of 1/1 and 1/2 on the back. The rate of decrease is not uniform, being very gradual to $h=0.30$ meter (0.984 foot), beyond which it changes rapidly, without doubt due to the detachment of the nappe.

Batter 1/2 on the downstream side.—Instead of decreasing as the head increases, $\left(\frac{m}{m'}\right)$ increases slowly in value between the limits 1.10 and 1.13, its value being nearly the same for the two batters on the back of 1/1 and 1/2.

Batter 1/5 on the downstream side.—In this case the coefficient ratio is nearly independent of h, decreasing from 1.015 to 1.000 for a batter on the back of 1/1, and from 1.045 to 1.035 for a batter on the back of 1/2.

WEIRS HAVING CRESTS 0.10 AND 0.20 METER (0.328 AND 0.656 FOOT) IN WIDTH.

The coefficient always increases with the head, but the limits between which this increase takes place differ in each case. If it were possible to increase the head indefinitely and at the same time the height of the weir, the conditions of discharge would approach progressively those for a sharp-crested weir, the width of the crest becoming more and more negligible, relative to the general dimensions of the dam. The series of coefficients relating to crests of a given width can not be, with certainty, extended beyond the experimental limits between which they were obtained. If, however, the curves representing the coefficients were sufficiently prolonged, they would converge toward those which correspond to a sharp-crested weir, with vertical faces. The batter on the back determines the direction of the filaments which constitute the inferior surface of the nappe and influences thus the contraction at the inner edge of crest, and hence also the discharge.

The batter on the downstream side, on the other hand, affects the pressure underneath the nappe.

When the width of the crest is not negligible, the inclination of the downstream face determines the limiting head at which the nappe detaches itself from the crest and at which point the conditions of discharge change suddenly. This limit depends also, in a certain measure, on the velocity of approach, or, which amounts to the same thing, on the ratio of the head h to the height p of the weir. A complete formula should include, in addition to the slopes of the two faces, the two ratios $\left(\frac{h}{c}\right)$ and $\left(\frac{h}{p}\right)$, where c is the width of the flat portion of the crest. Such a formula would be excessively complicated.

FOURTH GROUP—THE TWO FACES UNITED BY A CURVED SURFACE AT THE CREST OF THE WEIR.

Seven types of weirs were experimented on with a view to determining the effect on the discharge of joining the two faces of the weir by a curved surface, the slopes used being, on the upstream side, very nearly vertical (5/1), and on the downstream side from 1/3 to 1/5, the upstream edge of the crest being rounded to an arc of 0.05, 0.10, or 0.20 meter (0.164, 0.328, or 0.656 foot) radius.

Table No. 18 contains the values of $\left(\frac{m}{m'}\right)$ given by these series, for heads of 0.10, 0.20, 0.30, and 0.40 meter (0.328, 0.656, 0.984, and 1.312 foot), in comparison with those previously obtained from weirs having faces at the same slope and with crests 0.10 and 0.20 meter (0.328 and 0.656 foot) in width. Series Nos. 145, 146, 153, 155, and 156.

Types Nos. (1) and (2) differ only in regard to the radius of curvature of the back edge of the crest, this being 0.05 meter (0.164 foot) for the first and 0.10 meter (0.328 foot) for the second. The radius of 0.10 meter increases the discharge slightly more than that of 0.05 meter, though the difference is unimportant, but the values of $\left(\frac{m}{m'}\right)$ in both cases considerably surpass those which have been obtained for similar weirs with the two faces united by flat crests 0.10 and 0.20 meter (0.328 and 0.656 foot) in width. Series Nos. 145 and 153. Types Nos. (3) and (4) are similar to types Nos. (1) and (2) except as regards the inclination on the downstream side, which has been reduced from 1/3 to 1/5. This conduces to equalize the values of m, which differ relatively little from each other, although the values are sensibly less at the same heads than those for types Nos. (1) and (2), and yet somewhat greater than for weirs with flat crests 0.10 and 0.20 meter (0.328 and 0.656 foot) in width. Series Nos. 145, 155, and 156.

Types Nos. (5) and (6) differ only by the radius of curvature at the back, which is 0.10 and 0.20 meter, respectively, the crest being wider than in the preceding cases. The value of m is somewhat less than before, not differing greatly from that which corresponds to types Nos. (3) and (4).

The width of the crest is still further increased in type No. (7), the length of the rectilinear section between the origins of the two curved surfaces being 0.20 meter (0.656 foot). This modification produces a sensible diminution in the value of m.

FIFTH GROUP—WEIRS WITH COMPLETELY CURVED PROFILES.

We turn, finally, to the consideration of weirs having completely curved profiles. The coefficient m then attains exceptionally high values. The values of the ratio $\left(\frac{m}{m'}\right)$ for the six series of experiments are collected in Table No. 19. Types Nos. (1) and (2), having vertical downstream faces, permit of the formation of nappes wetted underneath. The corresponding coefficients are much higher than for the analogous case with a sharp-crested weir.

Types Nos. (3) and (4) have crests which differ only in the radii of curvature of the curved surfaces, being 0.05 and 0.08 meter (0.164 and 0.2624 foot), respectively, for type No. (3), and 0.10 and 0.12 meter (0.328 and 0.3936 foot), respectively, for type No. (4). The crest in this latter case is much larger, and the coefficient m is, as a result, notably less for heads up to 0.30 meter (0.984 foot), but it is not the same beyond this point, for the concave form of type No. (3) tends to produce detachment of the nappe, and the coefficient for this type continues to diminish from this point, becoming less than for type No. (4), in which the coefficient increases for all heads within the limits of the experiments.

Types Nos. (5) and (6) give, in spite of the difference of their profiles, nearly identical coefficients.[1]

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[1] See Annales des Ponts et Chaussées, Memoires et Documents, 2d quarter, 1898, pp. 151 to 194, inclusive.

[1]TABLE No. 13.—*Résumé of the first group. Weirs with the downstream face vertical or nearly vertical. Values of the ratio*

$$\frac{m}{m'} = \frac{\text{coefficient for experimental weir}}{\text{coefficient for a standard weir}}.$$

		Sharp-angled crest.				Crest 0.10 meter (0.328 foot) wide.							Crest 0.20 meter (0.656 foot) wide.		
Serial numbers.		125	126	127	128	36 and 54 Sharp-crested weir.	129	130	131	132	133	134	99 and 108 beam weir, 0.10 meter (0.328 foot) wide.	135	86 and 105 beam weir, 0.20 meter (0.656 foot) wide.
Batter of the faces.	Up-stream.	3/1	1/2	Vertical.	Vertical.		1/1	1/2	1/1	1/1	Vertical.	Vertical.		1/2	
	Down-stream.	Vertical.	Vertical.	3/1	3/2		Vertical.	Vertical.	3/1	3/2	3/1	3/2		Vertical.	
	Feet.	*Depressed nappes.*	*Depressed nappes.*	*Depressed nappes.*	*Depressed nappes.*	*Depressed nappes.*	*Depressed nappes.*	*Depressed nappes.*	*Depressed nappes.*	*Depressed nappes.*	*Depressed nappes.*	*Depressed nappes.*	*Depressed nappes.*	*Depressed nappes.*	*Depressed nappes.*
Head on crest of weir.	0.328	1.035	1.145	0.995	1.165	1.035	0.925	0.945	[2] 0.910	0.940	[2] 0.870	0.875	0.880	0.890	0.780
	0.492	[3] 1.080	[3] 1.185	1.020	1.170	1.035	[3] 1.015	[3] 1.015	1.015	1.020	1.005	0.900	[3] 0.880	[3] 0.940	[3] 0.835
	0.656	1.180	1.195	[3] 1.125	1.180	[3] 1.035	1.085	1.065	[3] 1.085	1.085	1.085	1.075	1.070	0.970	0.910
	0.820	1.145	1.180	1.115	[3] 1.160	1.130	1.120	1.095	1.115	1.130	[3] 1.145	1.145	1.130	1.000	0.960
	0.984	1.110	1.160	1.085	[4] 1.080	1.090	1.140	1.105	1.130	[3] 1.170	1.160	1.195	1.160	1.025	0.995
	1.148	1.080	1.145	1.045	1.055	1.060	1.145	1.105	1.140	1.140	[5] 1.165	[3] 1.210	1.160	1.040	1.030
	1.312	1.065	1.130	1.030	1.030	1.040	1.150	1.110	1.145	1.145	1.050	[6] 1.080	[7] 1.045	1.055	1.063

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[1] Tables Nos. 13 to 19 inclusive are translated from Bazin.
[2] Adhering nappes.
[3] Nappes wetted underneath.
[4] The form of nappe changes at a head of about 0.886 foot.
[5] The wetted nappe detaches itself from the crest at a head of about 1.148 feet.
[6] The adherent nappe is transformed into the form wetted underneath and detached from the crest at a head of 1.148 feet.
[7] Nappe detached from crest at a head of about 1.10 feet.

TABLE NO. 14.—*Second group. Increments of the coefficient ratio* $\left(\frac{m}{m'}\right)$ *for heads varying from 0.10 meter (0.328 foot) to the limits of the experiments.*

BATTER ON THE DOWNSTREAM FACE OF WEIR.

	Vertical.	3/1	3/2	1/1	1/2	1/3	1/4	1/5	1/6
Crest 0.328 foot wide *a*, upstream side vertical.	Vertical......	0.88 to 1.16 (Series No. 133)	0.89 to 1.21 (Series No. 134)	0.89 to 1.21 (Series No. 143)	0.88 to 1.03 (Series No. 144)	0.86 to 0.98 (Series No. 145)	1:4	0.83 to 0.90 (Series No. 146)	1 6
Crest 0.656 foot wide, upstream side vertical.	.....do........	.....do........	.....do	.....do	0.75 to 1.08 (Series No. 149)	.... do	1:4	0.78 to 0.91 (Series No. 155)	1:6
Crest 0.656 foot wide, batter 2/1 on upstream side.	.....do	.....do	.....do	0.82 to 1.12 (Series No. 147)	0.80 to 1.05 (Series No. 151)	0.86 to 1.00 (Series No. 153)	0.80 to 0.97 (Series No. 154)	0.80 to 0.95 (Series No. 156)	1:6
Crest 1.312 feet wide, upstream side vertical.	0.76 to 0.88 (Series No. 113)	.....do........	.....do........	.....do........	0.75 to 0.90 (Series No. 157)	.....do........	.....do........	.....do........	1:6
Crest 1.312 feet wide, batter 2/1 on upstream side.	.....do........	.....do........	.....do........	.....do........	0.79 to 0.93 (Series No. 158)	.....do........	0.80 to 0.89 (Series No. 159)	.....do........	0.80 to 0.88 (Series No. 160).
Crest 6.56 feet wide, both faces vertical.	0.70 to 0.76 (Series No. 115)	.....do........	... do........	.....do........	... do........	.....do........	.....do........	.....do	Do.

a The extreme values indicated for Series Nos. 133, 134, 143, and 144 correspond to the moment when the nappe is at the point of becoming detached from the crest. The value of $\frac{m}{m'}$ decreases rapidly when the nappe becomes detached.

TABLE No. 15.—*Résumé of the second group. Weirs with the upstream face vertical or nearly vertical. Values of the ratio*

$$\frac{m}{m'}=\frac{\textit{coefficient for experimental weir}}{\textit{coefficient for standard weir}}.$$

	Sharp-crested weirs.									Crest 0.10 meter (0.328 foot) wide.		Crest 0.20 meter (0.656 foot) wide.	
Number of series	136	137	138	139	140	141	142	143	144	145	146	147	148
Batter on back	Vertical	Vertical	Vertical	3/1	2/1	Vertical	Vertical	Vertical	Vertical	Vertical	Vertical	2/1	2/1
Batter on face	1/1	1/2	1/2	1/2	1/2	1/5	1/10	1/1	1/2	1/3	1/5	1/1	1/1
Height of weir, in feet	2.46	2.46	1.64	1.64	1.64	2.46	2.46	1.64	1.64	1.64	1.64	2.46	1.15
Head, in feet 0.328	1.105	0.990	0.995	1.050	1.065	0.880	0.820	0.885	0.865	0.850	0.825	0.820	0.785
0.492	1.125	1.010	1.030	1.065	1.080	0.890	0.825	0.995	0.945	0.915	0.870	0.870	0.860
0.656	1.125	1.015	1.040	1.070	1.090	0.900	0.830	1.065	0.995	0.960	0.890	0.930	0.900
0.820	1.130	1.020	1.040	1.075	1.090	0.905	0.840	1.140	1.040	0.980	0.900	0.980	0.960
0.984	1.130	1.020	1.045	1.075	1.090	0.910	0.840	1.180	1.060	0.985	0.905	1.025	1.010
1.148	1.130	1.020	1.040	1.075	1.090	0.905	0.845	1.205	1.050	0.985	0.905	1.070	1.040
1.312	1.130	1.025	1.035	1.070	1.085	0.905	0.845	1.145	1.040	0.985	0.905	1.090	1.050

	Weirs with crests 0.20 meter (0.656 foot) wide.							Crests 0.40 meter (1.328 feet) wide.				
Number of series	149	150	151	152	153	154	155	156	157	158	159	160
Batter on back	Vertical	3/1	2/1	2/1	2/1	2/1	Vertical	2/1	Vertical	2/1	2/1	2/1
Batter on face	1/2	1/2	1/2	1/2	1/3	1/4	1/5	1/5	1/2	1/2	1/4	1/6
Height of weir, in feet	2.46	2.46	2.46	1.15	2.46	2.46	1.64	2.46	2.46	2.46	2.46	2.46
Head, in feet 0.328	0.745	0.760	0.800	0.820	0.795	0.795	0.785	0.805	0.750	0.785	0.795	0.790
0.492	0.805	0.830	0.850	0.860	0.840	0.845	0.800	0.840	0.760	0.810	0.825	0.810
0.656	0.855	0.890	0.900	0.905	0.890	0.880	0.830	0.870	0.770	0.820	0.825	0.830
0.820	0.905	0.935	0.950	0.940	0.920	0.915	0.860	0.890	0.795	0.840	0.850	0.835
0.984	0.950	0.975	0.990	0.980	0.950	0.930	0.880	0.920	0.820	0.870	0.855	0.850
1.148	0.985	1.005	1.020	1.000	0.975	0.950	0.890	0.935	0.840	0.890	0.865	0.860
1.312	1.010	1.030	1.035	1.025	0.990	0.965	0.900	0.940	0.865	0.910	0.880	0.870

TABLE NO. 16.—*Résumé of the third group. Value of the ratio* $\frac{m}{m'} = \frac{\text{coefficient for experimental weir}}{\text{coefficient for standard weir}}$.

Batter on the upstream face.		Head, in feet.	Height of experimental weir, 0.50 meter (1.64 feet). Batter on the downstream face. 1/1	1/2	1/3
Sharp-crested weir	Serial number		161	163	165
	1/1	0.328	1.230	1.085	1.015
		0.656	1.205	1.110	1.005
		0.984	1.200	1.125	1.005
		1.312	1.110	1.125	1.000
	Serial number		162	164	166
	1/2	0.328	1.205	1.110	1.045
		0.656	1.190	1.120	1.040
		0.984	1.180	1.135	1.040
		1.312	1.125	1.135	1.035
Crest, 0.328 foot wide	Serial number		167	169	172
	1/1	0.328	0.930	0.915	0.875
		0.656	1.080	1.040	0.960
		0.984	1.150	1.100	0.990
		1.312	1.180	1.135	1.005
	Serial number		168	170	173
	1/2	0.328	0.950	0.950	0.905
		0.656	1.070	1.045	0.965
		0.984	1.110	1.090	0.995
		1.312	1.130	1.115	1.010
Crest, 0.656 foot wide	Serial number		174	177	180
	1/1	0.328	0.875	0.875	0.865
		0.656	0.960	0.950	0.915
		0.984	1.050	1.020	0.955
		1.312	1.095	1.055	0.970
	Serial number		175	179	181
	1/2	0.328	0.895	0.895	0.885
		0.656	0.970	0.960	0.925
		0.984	1.030	1.015	0.960
		1.312	1.080	1.050	0.980

TABLE NO. 17.—*Group three. Weirs with crests 0.10 and 0.20 meter (0.328 and 0.656 foot) wide. Showing variation of the ratio* $\frac{m}{m'}$.

Batter of the faces. Upstream.	Downstream.	Width of crest, 0.328 foot. $\frac{m}{m'}$, increases with the head.	Width of crest, 0.656 foot. $\frac{m}{m'}$, increases with the head.
1/1	1/1	From 0.930 to 1.180	From 0.875 to 1.095
1/2	1/1	From 0.950 to 1.130	From 0.895 to 1.080
1/1	1/2	From 0.915 to 1.135	From 0.875 to 1.055
1/2	1/2	From 0.950 to 1.115	From 0.895 to 1.050
1/1	1/5	From 0.875 to 1.005	From 0.865 to 0.970
1/2	1/5	From 0.905 to 1.010	From 0.885 to 0.980

TABLE NO. 18.—*Résumé of group four. The two faces of the weir joined by a curved surface, showing values of the ratio* $\frac{m}{m'} = \frac{\textit{coefficient for experimental weir}}{\textit{coefficient for standard weir}}$.

	Batter on the downstream face 1:3.							Batter on downstream face 1:5.				
	Upstream edge of crest rounded by a circular arc having a radius in feet of—					Crest not rounded; up stream face.		Crest rounded by a circular arc having a radius in feet of—		Crest not rounded; upstream face of weir.		
Radius	0.164	0.328	0.328	0.656	0.656	Vertical.	Batter 2:1.	0.164	0.328	Vertical.	Vertical.	Batter 2:1.
Type number	1	2	5	6	7	Crest 0.328 foot wide.	Crest 0.656 foot wide.	3	4	Crest 0.328 foot wide.	Crest 0.656 foot wide.	Crest 0.656 foot wide.
Serial number	182	183	186	187	188	145	153	184	185	146	155	156
Head, in feet 0.328	0.910	0.955	0.890	0.910	0.870	0.850	0.795	0.890	0.910	0.825	0.785	0.805
0.656	0.985	1.005	0.925	0.950	0.885	0.900	0.890	0.935	0.960	0.890	0.830	0.870
0.984	1.040	1.055	0.960	0.985	0.905	0.985	0.950	0.975	0.990	0.905	0.880	0.920
1.312	1.060	1.080	0.985	1.005	0.930	0.980	0.990	0.995	1.010	0.905	0.900	0.940

TABLE NO. 19.—*Résumé of group five. Weirs with completely curved profiles. Values of the ratio* $\frac{m}{m'} = \frac{\textit{coefficient for experimental weir}}{\textit{coefficient for standard weir}}$.

Type number	1	2	3	4	5	6
Serial number	189	190	191	192	193	194
Head, in feet 0.328	*a* 1.125	*a* 1.150	1.135	1.060	1.040	1.060
0.492	1.210	1.240	1.210	1.130	1.125	1.130
0.656	1.270	1.310	1.245	1.180	1.175	1.180
0.820	*b* 1.280	*b* 1.320	1.285	1.225	1.230	1.230
0.984	1.265	1.290	1.275	1.260	1.260	1.245
1.148	1.240	1.235	1.240	1.285	1.250	1.240

a Adherent nappes. *b* Nappes wetted underneath.

GENERAL RÉSUMÉ OF BAZIN'S EXPERIMENTS.[1]

This chapter has also been translated from Bazin's final paper in Annales des Ponts et Chaussées for 1898.[2]

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[1] Mémoires et Documents, 1898, pp. 219–223, inclusive.

[2] MATHEMATICAL SYMBOLS USED.

Bazin's formulæ have been changed so as to make English measures applicable by the introduction of a conversion factor when necessary. The mathematical symbols are as follows:

h = head on crest of weir, in feet.
u = mean velocity in channel above the weir, in feet.
a = a constant (replaces α, used by Bazin).
K = a constant.
g = acceleration of gravity, =32.2.
l = length of crest of weir, in feet.
n = a constant (replaces μ, used by Bazin).
p = height of crest of weir above bottom of channel, in feet.
m = coefficient of discharge over a given weir.
m' = corresponding coefficient for a standard weir.
Q = discharge, cubic feet per second.
h_1 = difference of elevation of crest of weir and of water on the downstream side, in feet, when the latter is below the crest of the weir.
h_e = difference of elevation of crest of weir and of water on the downstream side, in feet, when the weir is drowned.
c = width of crest of a flat-crested weir, in feet.
R = radius of curvature of a weir rounded at the back, in feet.
z = $h - h_e$, in feet.

CLASSIFICATION OF THE DIFFERENT SPECIES OF NAPPES.

When water is discharged through a submerged orifice, it is well known that the discharge Q varies according to the nature of the orifice. The coefficient m in the formula $Q = mc\sqrt{2gh}$ must be determined for each particular case. This coefficient varies, however, only within relatively narrow limits.

The conditions in the case of a weir are much more complex. The influence of the shape (width of the crest, degree of inclination of the upstream and downstream faces of the weir, etc.) always enters, but other factors conspire to make the value of the coefficient m in the classical formula $Q = mlh\sqrt{2gh}$ vary within much wider limits than for discharge through an orifice. The sloping nappe of a weir differs from the vein issuing from an orifice in that it may assume a variety of perfectly distinct forms. These forms constitute, in reality, as many distinct cases, each of which it is necessary to study separately, since by confusing them one must necessarily expose himself to serious errors. It is proper at the start to classify these different forms and to make known their distinctive characteristics.

Free nappes.—The most simple and definite case is that of a sharp-crested weir without lateral contraction, in which the nappe falls freely in the air, its lower surface always subject to the pressure of the atmosphere. The lateral contraction may be suppressed by making the length of the weir equal to the width of the canal leading to it, which is supposed to have vertical walls. Immediately below the crest these walls should be constructed in such a manner as to permit free access of air beneath the nappe, which then represents a portion of a nappe of infinite length. The resulting phenomena of flow are perfectly constant; the nappe, independent of any influence of the water below the weir, permits of a precise determination of the coefficient m.

Depressed nappes and nappes wetted underneath.—When the walls of the canal in which the weir is placed are not constructed in such a manner as to maintain free access of air beneath the nappe, the phenomena of discharge become more complicated and the form of the nappe, remarkably constant in the case where it falls freely over the weir, undergoes considerable modification, according to the amount of discharge.

When the head does not exceed a certain limit, the nappe remains detached from the face of the weir, imprisoning underneath it a volume of air at a pressure inferior to that of the external atmosphere. At the same time the water in the space between the foot of the nappe and that of the weir rises to a level above that of the stream below the weir. We have, then, a species of free nappe, modified and depressed by the excess of external pressure. The discharge over such a sharp-crested weir is, for equal heads, slightly greater than over a true free nappe. The difference increases as the volume of the imprisoned air diminishes.

Depressed nappes are not very stable; the accidental entrance of air from time to time produces variations in both the interior pressure and the discharge. When the air has entirely disappeared, the nappe takes a more definite form, which may be designated as wetted underneath. The overflowing nappe incloses a small portion of turbulent water, which does not partake of the translatory movement of the vein, properly speaking.

The occurrence of a nappe wetted underneath may be independent of the level of the water on the downstream side of the weir, or, on the contrary, it may be influenced by this level, every modification of which then reacts on the discharge over the weir.

The former is the case when the overfall is followed by a rapid which terminates in an abrupt ressault, below which the flow takes place in accordance with the condition of the channel. The position of the ressault is without influence on the discharge, provided that it does not inclose the foot of the nappe.

In the second case—that is to say, when the foot of the nappe is more or less inclosed in the water in the channel below the weir—it is not easy to separate the influence of the water in the channel, for the discharge may be modified although this water does not rise to the level of the crest of the weir.

Undulating nappes.—When the level of the water in the channel below the weir is raised to the height of the weir crest, the wetted nappe retains its form as long as the difference in level, or fall of the water from the upstream to the downstream side of the weir, does not descend below a certain limit. Its characteristic profile persists, although in part concealed by its immersion in the channel on the downstream side; but where the fall or difference in level is progressively diminished, a moment comes when the nappe returns suddenly to the surface, undulating in the meanwhile. This change, although very apparent, does not exert any important influence on the value of the coefficient of discharge.

Adhering nappes.—The forms of nappes thus far considered are those most ordinarily encountered. Another form exists, which appears under certain conditions, in which the nappe, instead of enfolding a small mass of turbulent water having no translatory movement, as in the case of the nappe wetted underneath, is, on the contrary, in close contact with the face of the weir. It presents then, in certain cases, some interesting particulars, and to this remarkable form there often corresponds a considerable increase of the coefficient of discharge.

The ensemble of the phenomena of discharge is very complex, and one can not often determine the discharge of a weir with precision without previously knowing under which particular form of nappe the discharge takes place. Taking, for example, a sharp-crested weir 0.75 meter (2.46 feet) high, we have shown that for the same head of 0.20 meter (0.656 foot) the nappe may assume four very distinct forms, to which correspond the following different values of the coefficient m in the formula $Q = mlh\sqrt{2gh}$:

	Meter.
(1) Free nappe, under surface always subjected to atmospheric pressure	0.433
(2) Depressed nappe, imprisoning a certain volume of air at a pressure below that of the atmosphere	.460
(3) Nappe wetted underneath, no air imprisoned, level of water on downstream side 0.125 meter (0.42 foot) below crest of weir	.497
(4) Adhering nappe, the ressault being at a distance from the foot of the nappe, which is completely exposed	.554

SHARP-CRESTED WEIRS.[1]

Free nappes.—When the nappe in flowing over a sharp-crested weir has its lower surface in free communication with the atmosphere, the only element which modifies the coefficient m is the mean velocity u in the channel leading to the weir. In order to take this into consideration in the formula, h is replaced by $h+a\left(\frac{u^2}{2g}\right)$. The formula becomes then, representing by n the modified coefficient m,[2]

$$Q=nl\left(h+a\frac{u^2}{2g}\right)\sqrt{2g\left(h+a\frac{u^2}{2g}\right)}$$

$$=nlh\sqrt{2gh}\left(1+a\frac{u^2}{2gh}\right)^{\frac{3}{2}}$$

or, approximately, considering that $\left(\frac{u^2}{2gh}\right)$ is a fraction rarely exceeding a few centimeters,

$$Q = nlh\sqrt{2gh}\left(1+\frac{3}{2}a\frac{u^2}{2gh}\right). \quad . \quad . \quad . \quad . \quad . \quad (1)$$

This expression is not in a form convenient for use, since the velocity u depends on the discharge to be determined. If p be used to designate the height of the weir above the bottom of the channel, the water section of the canal is $l(h+p)$, and we have

$$\frac{u^2}{2g}=\frac{Q^2}{2gl^2(h+p)^2}$$

or, simply replacing Q by its value $mlh\sqrt{2gh}$, we have

$$\frac{u^2}{2gh}=m^2\left(\frac{h}{h+p}\right)^2$$

Letting, for short, $\left(\frac{3}{2}am^2\right)=K$, the above expression takes the more practical form

$$Q = n\left[1+K\left(\frac{h}{h+p}\right)^2\right]lh\sqrt{2gh} \quad . \quad . \quad . \quad . \quad (2)$$

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[1] Annales des Ponts et Chaussées. Mémoires et Documents, 1898, p. 223.

[2] Annales des Ponts et Chaussées, 1888, p. 417 and following.

We have determined the coefficients a, K, and n by comparative experiments on five weirs of different heights.[1] a and K are not perfectly constant, but one may take, as a mean, $a=\frac{5}{3}$; K=0.55. As to n, its value, which corresponds to the limiting case of no velocity of approach, can not be measured directly, since it is impossible to completely suppress this velocity. Its influence becomes, however, insignificant in a high weir. The coefficient n decreases slowly as the head increases, as shown below:

Head, feet = 0.164, 0.328, 0.656, 0.984, 1.312, 1.640.
Corresponding values of n = 0.448, 0.432, 0.421, 0.417, 0.414, 0.412.

When h is over 0.328 foot, its value is represented with sufficient precision by the formula

$$n=0.405+\left(\frac{0.00984}{h}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Adopting for K the value 0.55, formula (2) becomes

$$m=n\left[1+0.55\left(\frac{h}{h+p}\right)^2\right] \quad . \quad . \quad . \quad . \quad . \quad (4)$$

In most cases where the head falls between 0.10 meter (0.328 foot) and 0.30 meter (0.984 foot), n may be taken at the constant value 0.425, and taking $K=\frac{1}{2}$ simply, the expression for m becomes

$$\left.\begin{aligned} m&=0.425\left[1+\frac{1}{2}\left(\frac{h}{h+p}\right)^2\right] \\ &=0.425+0.212\left(\frac{h}{h+p}\right)^2 \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

which will answer for all practical cases where errors of 2 to 3 per cent are permissible. It is this coefficient of discharge m, perfectly determined by the head h and the height p of the weir, which has been used for comparison. Instead of considering on the other weirs the absolute values of the coefficient m, we have compared them with the coefficient m' for a free nappe, for the same head on a sharp-crested weir of the same height. This substitution of the ratio $\frac{m}{m'}$ for the absolute values of m eliminates, in a large measure at least, the influence of velocity of approach and facilitates greatly the discussion of results.

In what precedes, the upstream face of the weir has been supposed to be a vertical plane. If it is inclined, the values of the coefficient m will be modified. The coefficient is diminished when the plane of the dam is inclined upstream; but if, on the contrary, the plane of the dam is inclined downstream, the coefficient increases to a maximum which corresponds nearly to an inclination of 30° (equals a batter on the back of 1¾:1).[1] The ratio between the coefficients corresponding to two different inclinations is sensibly constant for all heads, so that one may obtain the coefficient m for a sharp-crested weir at any inclination by multiplying by a constant, or modulus, the corresponding coefficient for a vertical weir, as is indicated in the following table.

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[1] Annales des Ponts et Chaussées, Mémoires et Documents, 1888.

This ratio increases regularly from an inclination of 45° toward the upstream side to approximately 30° toward the downstream side, where the maximum occurs, from which point the discharge does not take place in the normal manner, since the liquid vein in its passage over the crest, instead of being freely contracted, is guided by the incline of the weir on which it rests in immediate contact.

	Modulus by which to multiply the coefficient for a vertical weir.
Upstream inclination of the weir:	
1 horizontal to 1 vertical	0.93
2 horizontal to 3 vertical	.94
1 horizontal to 3 vertical	.96
Vertical weir	1.00
Downstream inclination of the weir:	
1 horizontal to 3 vertical	1.04
2 horizontal to 3 vertical	1.07
1 horizontal to 1 vertical	1.10
2 horizontal to 1 vertical	1.12
4 horizontal to 1 vertical	1.09

Sharp-crested weirs—Nappes depressed and wetted underneath.—When the air is not admitted freely underneath the nappe the phenomena become more complicated. The nappe may be either depressed, as a result of air being imprisoned underneath at less than atmospheric pressure, or it may be wetted underneath without containing any air. The discharge for a depressed nappe is slightly in excess of that for a free nappe. The difference may rise to nearly 10 per cent at the moment when the nappe, the confined air being nearly exhausted, is at the point of assuming the form of a nappe wetted underneath. The accidental entrance of air from time to time may vary the discharge a little. The wetted nappes are more uniform. It is important to distinguish two cases according as the ressault, which is produced below the nappe, is at a distance from its foot or partly incloses it.

First case—Ressault at a distance.[2]—The coefficient m may be deduced from the coefficient m' for a free nappe by the relation[3]

$$m=m'\left[0.878+0.128\frac{p}{h}\right] \quad . \quad . \quad . \qquad (6)$$

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[1] Annales des Ponts et Chaussées, Mémoires et Documents, 1890, pp. 18 to 27.

[2] See Annales des Ponts et Chaussées, 1894, Mémoires et Documents, pp. 251-253, 261, 264, 265.

[3] See Annales des Ponts et Chaussées, Mémoires et Documents, 1894, p. 258.

The ratio $\left(\frac{p}{h}\right)$ can only have certain values, as experience has shown that it does not exceed 2.5, because the form of nappe wetted underneath does not continue if the head is less than 0.4 p. For the maximum value $\frac{p}{h}=2.5$, we have, very nearly, $m=1.20m'$; and when $h=p$, m becomes sensibly equal to m'. Finally, m is a little greater than m' when h surpasses p.

If the above formula be applied to weirs of different heights it may be shown that for the same value of $\left(\frac{p}{h}\right)$ the absolute values of m do not differ greatly from those given by the equation[1]

$$m=0.470+0.0075\frac{p^2}{h^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

which permits us to find an absolute value of the coefficient m without using the ratio $\left(\frac{m}{m'}\right)$.

Second case—The ressault inclosing part of the nappe.[2]—It is necessary to take into account the level of the water below the weir, and, if we designate by h_1 the difference of level of the crest of the weir and of the water below, the value of m becomes[3]

$$m=m'\left[1.06+0.16\left(\frac{h_1}{p}-0.05\right)\frac{p}{h}\right] \quad . \quad . \quad . \quad . \quad (8)$$

In this formula h_1 is to be taken as minus when the level of the water on the downstream side is below the crest, and as plus when it is above the crest. The formula can only be applied within certain limits of h_1. If the difference in level of the water above and below the weir be increased a moment comes when the ressault is driven back from the foot of the nappe until it ceases to inclose it and changes then to the preceding case. This pushing back of the ressault takes place when the total fall $(h+h_1)$ is approximately equal to $\frac{3}{4}\,p$; that is to say, for a given head h the greatest admissible value of h_1 is $(\frac{3}{4}\,p-h)$. On the other hand, when the head h is insufficient to throw back the ressault it is necessary that the level below the weir be sufficient to sustain the foot of the nappe and to prevent the introduction of air, which would cause the nappe to return to the depressed form. The preceding formula may be simplified by suppressing the small term, 0.05, in the parenthesis, and for compensation slightly diminishing the two other coefficients. It then becomes

$$m=m'\left(1.05+0.15\,\frac{h_1}{h}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

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[1] Annales des Ponts et Chaussées, Mémoires et Documents, 1894, p. 259.

[2] See Annales des Ponts et Chaussées, Mémoires et Documents, 1894, pp. 280–283).

[3] See Annales des Ponts et Chaussées, Mémoires et Documents, 1894, p. 284.

Sharp-crested weirs—Adhering nappes.—The nappe may also take, though very rarely, a particular form, the production of which depends on the width of the dam and the form of the upper part supporting the sharp crest. The nappe becomes completely attached, without the interposition of air, to the downstream face of the dam. The coefficient of discharge then becomes very large and may rise as high as 1.30 m', which corresponds to an absolute value of the coefficient $m=0.55$ or 0.56.[1] Adhering nappes present some curious particulars, but as they only occur exceptionally in practice, we may simply refer to the special studies made of them included in Annales des Ponts et Chaussées for 1891.

Beam weirs—Free nappes.—Beam weirs are constructed of square timbers of the same cross-sectional dimensions, placed one upon another to the desired height. The back and front faces of the weir are vertical planes, but the crest, instead of being reduced to a sharp edge, presents a horizontal surface, the width of which equals the thickness of the timbers. This circumstance completely modifies the conditions of discharge, and, while this form of weir is readily constructed, it may, unfortunately, give considerable error in the gaugings.

The free nappes[2] appear under two distinct forms, according as the nappe is in contact with the horizontal crest or becomes detached at the back edge in such a manner as to flow over the crest without touching the downstream edge. In the second case the influence of the flat crest evidently disappears and the discharge is like that over a sharp-crested weir. The nappe assumes this form when the head exceeds twice the width c of the crest measured in the direction of discharge, but it may occur whenever the head exceeds $\frac{3}{2}c$. Between these limits the nappe is in a state of instability. It tends to detach itself from the crest, and may do so under the influence of any external disturbance, as, for example, the entrance of air or the passage of a floating body over the weir.

When the nappe adheres to the crest, the coefficient m depends chiefly on the ratio $\left(\frac{h}{c}\right)$, and may be represented by the formula[3]

$$m=m'\left[0.70+0.185\frac{h}{c}\right] \quad . \; . \; . \; . \; . \; . \quad (10)$$

m varies, as a consequence, very rapidly. We have,

When $\frac{h}{c}=0.50 \qquad \frac{m}{m'}=0.79$

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[1] See Annales des Ponts et Chaussées, Mémoires et Documents, 1891, series Nos. 40 to 51.

[2] See Annales des Ponts et Chaussées, Mémoires et Documents, 1891, pp. 648–650.

[3] See Annales des Ponts et Chaussées, Mémoires et Documents, 1896, p. 653.

$$\frac{h}{c}=1.00 \qquad \frac{m}{m'}=0.88$$

$$\left.\begin{array}{ll}\dfrac{h}{c}=1.50 & \dfrac{m}{m'}=0.98 \\ \dfrac{h}{c}=2.00 & \dfrac{m}{m'}=1.07\end{array}\right\}\text{or 1.0 if the nappe is detached.}$$

When $\frac{h}{c}$ exceeds 2.00, $\frac{m}{m'} = 1.00$. It will be seen that between $h = \frac{3}{2} c$ and $h = 2 c$, $\frac{m}{m'}$ may vary from 0.98 to 1.07, or nearly a tenth in value, or it may remain constantly equal to unity, according as the nappe is attached to or free from the crest.

Very wide crests.—When the width of the crest is considerable, 1 or 2 meters, for example,[1] the linear formula (10) is stlll applicable, giving results within a few per cent. The value of $\left(\frac{h}{c}\right)$ then reduces to a few tenths and the ratio $\left(\frac{m}{m'}\right)$ also becomes much smaller, so that m may not exceed 0.35. For example, at a head of 0.45 meter (1.476 feet) on a weir with a flat crest 2 meters wide, $\frac{m}{m'} = 0.755$, which corresponds to an absolute value of $m = 0.337$. The formula gives $\frac{m}{m'} = 0.732$, and as a result $m = 0.326$.

Effect of rounding the crest at back.—A slight rounding of the back edge of the crest very sensibly modifies the discharge. Fteley and Stearns[2] have shown that rounding the back of edge of the crest to a radius R augments the discharge by an amount equal to that given by a head increased by 0.7 R. This is equivalent to increasing the coefficient m in the ratio of $h^{\frac{3}{2}}$ to $(h + 0.7\ \mathrm{R})^{\frac{3}{2}}$ or nearly in the ratio of 1 to $1 + \frac{\mathrm{R}}{h}$. The radius R in their experiments did not exceed 0.039 foot, and it is clear that this approximate mode of correction will not apply to cases where the radius is notably greater. We have experimented on two weirs, respectively 0.80 meter (2.624 feet) and 2 meters (6.56 feet) in width, with crests rounded at the back to a radius of 0.10 meter (0.328 foot), and this modification has had the effect of increasing the discharge 14 per cent on the first of these weirs and 12 per cent on the second. A simple rounding of 1 or 2 centimeters radius, such as results from wear on timbers of ordinary dimensions, is by no means negligible from the point of view of the resulting discharge.

A weir with a crest 2 meters wide and rounded at the back gave for the largest head used in the experiments, $m = 0.373$, a value differing little from that indicated by theory for the case of a nappe flowing in filaments parallel to the horizontal surface of the crest. This hypothesis may not, however, be realized experimentally in more than a very imperfect manner, as the surface of the nappe continually undulates.

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[1] See Annales des Ponts et Chaussées, Mémoires et Documents, 1896, p. 678.

[2] See Transactions American Society Civil Engineers, 1883.

Beam weirs—Nappes depressed and wetted underneath.—The depressed nappes do not differ greatly from the free. The coefficient is at first less than for a free nappe, but approaches it progressively in value and finally exceeds it slightly. It differs in this respect from a sharp-crested weir, for which the coefficient for a depressed nappe is always superior to that for a free nappe. It makes no difference as to this whether the nappe clings to the flat crest or is detached from it. In either case the coefficient differs little from that for a sharp-crested weir. The effect of adherence to the flat crest appears again for a nappe wetted underneath, with this added difficulty, that the moment of detachment underneath the water is not apparent and does not correspond to any constant value of $\left(\frac{h}{c}\right)$. In other words, it may take place either preceding or following the formation of the nappe wetted underneath. It is necessary, in this regard, to distinguish two cases according as the height p of the dam is greater or less than about five times the width c of the crest. When p is greater than $5\,c$, the nappe detaches itself from the flat crest before it becomes wetted underneath, and in the intermediate state does not differ greatly from that for a sharp-crested weir. When, on the other hand, p is less than $5\,c$, the nappe does not detach itself from the flat crest before becoming wetted underneath, but is very unstable at the moment of this transformation.

So long as the nappe adheres to the crest this influence predominates and formula (10) is most nearly applicable to the nappe wetted underneath. On the other hand, when the nappe is detached from the flat crest the conditions of discharge approach more nearly those for a sharp crest, to which formula (6) may be applied. The two formulæ give the same value when the head exceeds a certain limit

$$h_1 = \frac{c}{2}\left[1+\sqrt{\frac{3\,p}{c}}\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

For heads less than h_1 formula (10) gives values of m slightly too small, never differing from those of the experiments, however, by more than 3 or 4 per cent. When the head exceeds h_1, one must take recourse to the other formula, although it likewise gives too small values. The difference, rather more important in this case, attains 8 per cent as a maximum, after which it diminishes rapidly for increased heads. This maximum corresponds to the moment when the nappe is at the point of detaching itself from the flat crest. After it has become detached, the influence of the width of the crest disappears and formula (6) applies to a very close degree of approximation.

It will be seen that the flat crest has the effect of doubling each species of nappe, in that two formulæ must be applied according as the nappe clings to or is detached from the flat surface.

Weirs with wide crests and batter on the faces.—The phenomena of discharge become much more complex for weirs, such as are often found in practice, with batters of greater or less inclination on the front and back faces. The influence of the flat crest, which exerts itself in a weir built up of square timbers, is joined to that of the slope of the faces. The inclination of the upstream face, by reducing the contraction, has the effect of increasing the discharge, while that of the downstream face has ordinarily the same effect as increasing the width of the flat crest; that is to say, it diminishes the discharge. The coefficient m, then, in each particular case depends not only on the head, but on the width of the crest and the degree of inclination of the faces. It is therefore exceedingly variable, and each type demands a special study.[1]

Rounding the back edge of the crest reduces the contraction considerably and may increase the value of m 10 or 15 per cent. Considering, finally, the class of weirs with completely curved profiles, such as are occasionally encountered in hydraulic practice, the value of m may attain a relatively high figure. The coefficients for such cases have not been arranged in comparative tables, but enough particular cases are given to serve as a guide in practice. It is clearly impossible to establish a general formula which shall take account of all the elements that enter to affect the discharge.

Drowned weirs.—We have given, in discussing the experiments on sharp-crested weirs drowned by the water on the downstream side,[2] two formulæ, one of which applies to cases where the weir is not deeply drowned. The other, which is more general in its application, is[2]—

$$m=m'\left[1.08+0.18\frac{h_1}{p}\right]\sqrt[3]{\frac{z}{h}} \quad . \quad . \quad . \quad . \quad . \quad (12)$$

in which

h=head on crest of weir.

p=height of weir above bottom of stream channel.

h_1=difference of elevation of crest of weir and of water on downstream side when the weir is drowned.

$z=(h-h_1)$

m=coefficient of discharge.

The two formulæ mentioned have been so established as to represent in the best possible manner the experiments from which they have been deduced.[3] In cases where a less precise approximation will suffice the above formula may be made more applicable by slightly altering its coefficients as below:

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[1] See series Nos. 125 to 194, the results of which are epitomized by groups in the tables on pp. 154 to 194, Annales des Ponts et Chaussées, 1898.

[2] See Annales des Ponts et Chaussées, Mémoires et Documents, 1894, pp. 289–297.

[3] See Annales des Ponts et Chaussées, Mémoires et Documents, p. 310, table.

$$m=1.05\,m'\left[1+\frac{1}{5}\left(\frac{h_e}{p}\right)\right]\sqrt[3]{\frac{z}{h}} \quad . \quad . \quad . \quad . \quad . \quad (13)$$

This new expression is practically equivalent to the two others and gives the same values within 1 or 2 per cent, except when the ratios $\left(\frac{h}{p}\right)$ and $\left(\frac{h_1}{p}\right)$ are very small. The difference may then be as much as 4 or 5 per cent, but in this case the determination of the coefficient m is always very uncertain.

The effect of drowning is not the same for a wide-crested weir.[1]

Raising the plane of the water below the weir, which in the case of a sharp-crested weir affected the flow on the upstream side before the water below had reached the height of the crest, does not commence to take effect on a wide-crested weir until after the level of the water on the downstream side is considerably above the crest; and the greater the width of the crest the less is its ultimate effect. In our experiments on a crest 2 meters in width we have shown that the water on the downstream side must rise to a height above the crest equal to $\frac{5}{6}$ of the head h before it affects the level on the upstream side.

When the plane surface which forms the crest of a weir is very wide, it constitutes a sort of channel and, in a measure, as the length of this channel is increased the conditions of discharge depart from those which pertain to a weir, properly speaking, and approach those for a channel with a horizontal bottom.

THE CORNELL UNIVERSITY EXPERIMENTS.

At the beginning of the study of Bazin's work it was the author's opinion that his coefficients could be fairly extended to depths on the crest of about 4 feet without material error, and on this basis the original discharge curves, plates 107 to 126, inclusive, were worked out in the manner already described. On further study, however, it seemed probable that some of his series, especially Nos. 130 and 135 and a few others, might be somewhat too high for deep flows, for the reason that at depths on the crest from 0 up to about 0.6 foot to 1.0 foot the nappes were depressed and adherent, and above 0.6 foot to 1.0 foot were wetted underneath, thus indicating that probably the conditions of the experiment were such as not to insure free admission of air beneath the nappe, this condition leading to higher flows than would occur with air freely admitted.

Again, Bazin's weirs were constructed with closed fronts, thus offering an opportunity for adhering nappes, while in actual practice, for sections corresponding to series Nos. 130 and 135, the water generally flows over a lip, the nappe dropping into a free air space below. This general condition is illustrated by the dams shown on plates 110, 115, 122, and others. The conditions at the ends of such dams are such as to usually permit admission of air.

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[1] See Annales des Ponts et Chaussées, 1896.

On April 14, 1899, the author visited the new Cornell University Hydraulic Laboratory and at once saw that a fine opportunity was offered there to experiment on flows over weirs at much higher heads than had hitherto been possible, and on communicating his views to your Board he was permitted to undertake a series of experiments in cooperation with the university authorities. Messrs. Wallace Greenalch, Robert E. Horton, and George E. Cook were detailed from the engineering corps for this work, which was done in cooperation with Prof. Gardner S. Williams, engineer in charge of the hydraulic laboratory, permission to use the same having been obtained by correspondence with Prof. E. A. Fuertes, director of the Cornell University College of Civil Engineering. The author gave the experiments general supervision, the working out of the details being mostly left to Mr. Greenalch and Professor Williams, Mr. Greenalch undertaking to construct the necessary flumes, bulkheads, experimental weirs, etc., and Professor Williams preparing and taking charge of the measuring apparatus.

Plate 131 gives a plan and section of the experimental channel at the Cornell University hydraulic laboratory. This laboratory has been quite fully described in Engineering News for March 2, 1899, and no further description will be made here than necessary to explain the experiments.

DESCRIPTION OF THE ARRANGEMENTS FOR THE EXPERIMENTS.

The canal in which the experiments were made consists briefly of a channel with sides and bottom of concrete, 418 feet long, 16 feet wide, and 10 feet deep. The grade of the bottom of the channel is at the rate of 1 foot in 500. A bulkhead composed of 12 by 12-inch timbers, situated about 60 feet from the upper end, divides the channel into two chambers. A standard sharp-edged weir, 16 feet in length, was placed on this bulkhead, the crest of the weir being 13.13 feet above the bottom of the channel. The upper chamber above the bulkhead has higher side walls than the lower chamber, which admitted of a depth of 17.7 feet of water. At the lower end of the channel another timber bulkhead closes the lower chamber, and on which the weirs to be experimented upon were built. The top of this bulkhead was about 4.8 feet above the bottom of the channel. The heights vary slightly for each experimental weir, the exact height of each weir being shown on the sections at the head of the tabulations of results.

In order to obtain heads on the lower weir of about 5 feet, the 16-foot channel was narrowed to a width of 6.56 feet (2 meters) by means of a wooden flume, as shown on plates 131. This flume was 6.56 feet wide for a distance of 48 feet above the lower bulkhead and then expanded to a width of 16 feet in a length of 8.3 feet, as shown. The flume was constructed of matched white-pine boards 1.75 inches thick, planed on the inside and held in place by bents of 4 by 4-inch timbers. As the lower bulkhead was water-tight for the whole width of the channel, no attempt was made to construct the sides and bottoms of the flume absolutely water-tight, although they were practically so. Inasmuch as nearly equal water pressure on both sides of the flume would permit of greater economy in construction, two boards were left off on each side at the upper end, thus allowing water to enter at the sides between the flume and the concrete walls of the main canal. This arrangement also greatly diminished the area of water-tight work. The sides of the flume were extended from 8 to 24 feet below the bulkhead, according to the form of weir experimented on, thus preventing lateral expansion of the nappe after passing the weir and crest. Openings were left in each side of this extension below the level of the crest in order to certainly allow free access of air under the nappe. The vertical fall of the water from the crest of the experimental weir to the rock below was about 12.2 feet.

There is a pond of 22 acres area above the main reservoir dam, the surface of which was raised about 1.7 feet by means of flash boards placed in the main spillway. The water surface thus obtained was about 5.4 feet above the crest of the standard weir. Water from the reservoir was admitted into the upper chamber through six wooden sluice gates, operated by rack-and-pinion apparatus with long levers.

The sharp-edged standard weir was composed of a 3.5 by 5 inch steel angle, secured by lag screws to a 6 by 12 inch oak timber, as shown on plate 131. After bolting the angle iron into place on the timber the edge of the 5-inch leg was planed and dressed to a true line five-sixteenths of an inch in width and carefully leveled in position on the upper bulkhead. Air was freely admitted under the nappe by means of deflecting boards at each end of the weir, as shown on plate 131. The fall of the water from the crest of the standard weir to the water surface in the lower chamber varied from about 3 to 8 feet, according to quantity of water flowing.

The velocity of the water passing through the regulating gates at the extreme head of the channel was checked by three screens in the upper chamber. The first two consisted of 4 by 12 inch timbers placed horizontally with the wide face toward the current and spaced from 8 to 12 inches apart. Below these was a third screen of one-quarter-inch mesh galvanized wire netting. A screen composed of 1 by 8 inch boards laid horizontally with the edges to the current and spaced 2 inches apart was placed about 20 feet below the upper bulkhead, and served to quiet the water in the lower chamber.

The heads of the weirs were measured by means of piezometers constructed as follows: A 1-inch galvanized-iron pipe with holes one-quarter inch in diameter and spaced 6 inches apart was laid across the channel about 8 inches above the bottom, with the holes therein opening downward. Connections with these pipes were made by three-quarters-inch pipes passing through the bulkhead to a point below the weir, where the gauges could easily be connected by rubber hose. The gauges were glass tubes three-quarters inch internal diameter, mounted on wooden standards, and read by a scale gradūated to 2 millimeters spaces. Three piezometers were set at each weir, as shown on plate 131, though readings were taken only on the upper two. In order to check the accuracy of the piezometric readings, after the conclusion of experiment No. 17 a fourth piezometer pipe was set in the bottom of the flume above the lower bulkhead and about 6 inches upstream from the upper piezometer. This pipe was set with one-quarter-inch holes directly on top and with the top of the pipe flush with the bottom of the flume. Readings were taken simultaneously on both piezometers and considerable differences noted.

At the lower weir the height of the flowing water in the flume and of the still water behind the flume was read on scales marked on the side of the flume. These scales were divided to 0.05 foot and read by interpolation to 0.01. Similar gauges were set in the upper chamber and in the reservoir, and readings of each taken every five minutes.

In addition to the gauge board in the upper chamber, a float gauge, read by dial to 0.01 foot, was set directly over the upper piezometer. The float of this dial gauge was a heavy, sheet-tin, air-tight vessel, weighted with shot and caused to move vertically with the water in the interior of a length of 8-inch cast-iron pipe suspended from two timbers across the upper channel. The dial was placed in such position as to be easily read by the assistants operating the gates at the upper end of the channel, thus insuring that the depth over the standard weir be easily maintained at substantially a constant head, as required.

The experimental weirs of different sections were all made of planed white-pine boards about 1 inch thick, so fastened together with screws as to be easily removable. Leakage from the bulkheads and gates at the lower end of the channel was effectively stopped by calking with oakum and pitch and also by the application of wheat bran from time to time.

Observations showed that the upper bulkhead was practically water-tight, but at the side gates, near the lower bulkhead, there was a slight leakage, which has been taken at one-half a cubic foot per second for high heads and one-quarter of a cubic foot per second for low heads, and proportionally between. The main channel, with side walls of concrete, is considered to be water-tight.

The foregoing allowances for leakage are taken to cover the slight evaporation and absorption loss into the sides of the main channel.

REDUCTION OF THE EXPERIMENTS.

The method of conducting the experiments was, in general, as follows: The main head gates at the entrance to the canal were opened to such a width that the dial gauge showed a head of 3 feet above the standard 16-foot weir. They were retained in this position until a uniform regimen of flow was established in the canal and maintained for a period of from ten to twenty minutes, during which time the piezometers were read at both weirs at intervals of thirty seconds. At the close of such a period the head gates were lowered until the dial gate showed a reading of 2.5 feet head on the upper weir, sufficient time being allowed to elapse to establish and maintain a new regimen of flow the same as before. In this way piezometric observations were taken during several periods at different heads in each experiment, usually terminating with a head of about 6 inches or 1 foot on the upper weir. In some cases the varying of the head on the upper weir by uniform decrements of 6 inches was not adhered to.

The method of treating the piezometric readings, obtained as described in the preceding paragraph, is shown on plates 132 and 133. On plate 132 the upper curve shows the readings taken at the upper weir (16 feet in length) and the lower curve the readings taken at the lower experimental weir for experiment No. 14 on the Rexford Flats Dam. These two curves, as plotted, show the actual readings taken, in centimeters, without corrections of any sort or kind. The several periods (A—A) of the upper curve and the corresponding periods (B—B) of the lower curve represent the actual periods taken in the reductions for each height experimented upon. A mean of the actual readings for these periods has been taken as the mean head during each experimental period.

On plate 133 we have a plotting of similar curves for experiment No. 20 on sharp-crested weir, made June 10, 1899. The explanations for plate 132 apply equally to this plate. Attention may be directed to the method of exhibiting the continuous curve of flow, as shown on plates 132 and 133. Its use in the present case is to be credited to Prof. Gardner S. Williams, engineer in charge of the Cornell University Hydraulic Laboratory. The author has never seen it used before, and if it is original with Professor Williams he is entitled to very great credit for this particular feature of the experiments.

In order to calibrate the upper weir (16 feet in length), and thereby determine the quantity of water flowing in the lower canal and over the experimental weirs, experiments Nos. 20 and 21 were made. These experiments apply to a sharp-crested weir of standard form, 5.26 feet in height, placed in the lower end of the canal. As a basis for the reduction of experiments Nos. 20 and 21 a discharge curve has been computed for the upper weir (16 feet in length) for heads up to 0.6 meter (1.969 feet), using Bazin's formula,

$$Q = \mathrm{MLH}\sqrt{2g\mathrm{H}},$$

$$\mathrm{M} = n\left[1+0.55\left(\frac{\mathrm{H}}{p+h}\right)^2\right]$$

$$m = n\left[1+0.55\left(\frac{h}{p+h}\right)^2\right]$$

in which

Q=discharge over weir, in cubic feet, per second;
h=observed head on crest, in feet;
h_v=correction for velocity of approach;
H=head on weir corrected for velocity of approach $= h+h_v$;
m=coefficient of discharge in the formula $mlh\sqrt{2gh}$;
M=coefficient of discharge in the formula $\mathrm{MLH}\sqrt{2g\mathrm{H}}$;
C=coefficient in the Francis formula $\mathrm{C} = \mathrm{M}\sqrt{2g}$, when g is expressed in feet;
p=height of crest of weir above bottom of channel of approach, in feet;
n=a coefficient which depends on p and h, and which has been taken from Bazin's table.[1]

In the réduction of experiments Nos. 20 and 21 the mean readings of the middle piezometer at the upper weir (16 feet in length) were added to the difference of elevation of the gauge zero and of the mean crest as a basis for computing the flow in the upper channel. The discharge corresponding to the heads so obtained was then taken off of the discharge curve computed from Bazin's formula for all the periods in which the observed head was less than 0.6 meter (1.969 feet). The approximate correction to be applied for velocity of approach to the standard weir was then computed, as follows:

Let H=the true head on the crest of the weir, in feet;
h=the observed head, in feet;
Q_h=discharge over the weir under the head h, per linear foot of crest;
Q=discharge under the head H, per linear foot of crest; and
p=height of weir crest above channel bottom, in feet.

Then velocity of approach $= v = \sqrt{2g\,(\mathrm{H}-h)}$,

also,

$$v = \frac{Q}{p+h} = \frac{Q}{A}, \text{ and } \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$h_v = (\mathrm{H}-h) = \frac{v^2}{2g} = \left(\frac{Q}{A}\right)^2 \times \frac{1}{2g} \quad . \quad . \quad . \quad . \quad (2)$$

Q_h being determined from the discharge curve, an approximate value of v and of the corresponding velocity head was computed and the approximate value of the velocity head so obtained added to the observed head h, which was used in determining Q, v, and (H—h) with more precision. Generally two successive applications of these formulæ were found sufficient to determine the velocity head with the desired degree of accuracy. In this way the final corrected head $H=(h+h_v)$ was obtained. After applying a correction for leakage, percolation, and surface evaporation, the corresponding discharges by Bazin's formula have been used in determining the coefficients for the sharp-crested experimental weir (6.53 feet in length) for heads up to 3.5 feet, as produced by heads not exceeding 2 feet on the upper weir (16 feet in length).

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[1] See Annales des Ponts et Chaussées, Mémoires et Documents, 1888, p. 446.

The foregoing correction for velocity of approach is merely the addition to the observed heads of

$$\frac{v^2}{2g}$$

as determined for the actual flows of each experiment. Messrs. Fteley and Stearns have experimented on the effect of velocity of approach, especially with reference to that part of it represented by the vis viva of the water, and state in their classical paper in the transactions of the American Society of Civil Engineers for January, February, and March, 1883, that for the conditions of their experiments corrections of velocity of approach to be added to the observed heads are best represented by

$$1.45 \text{ to } 1.50\times\left(\frac{v^2}{2g}\right)$$

The problem of correction for velocity of approach is discussed at length by Hamilton Smith in his Hydraulics, the conclusion being that for a weir with full contraction and having an unobstructed channel of considerable length the correction should be about

$$1.1 \text{ to } 1.25\times\left(\frac{v^2}{2g}\right)$$

For end contractions suppressed he adopts the values

$$1.33\times\left(\frac{v^2}{2g}\right) \text{and } 1.40\times\left(\frac{v^2}{2g}\right)$$

In the present case it has seemed preferable to use

$$h_v=\frac{v^2}{2g}$$

although the entire suppression of end contractions might appear to indicate a higher correction for the velocity of approach. This view, however, is based upon other considerations, namely, the actual locations of the piezometers.

Messrs. Fteley and Stearns have pointed out that for standard sharp-crested weirs the head should be measured about 6 feet back from the crest; but in the present case the heads have been measured much farther back. At the upper 16-foot weir the heads were measured at the middle piezometer for all experiments except Nos. 1, 2, 3, and 4, for which they were measured at the upper piezometer. These latter observations have been reduced to the basis of the middle piezometer, which was 10 feet back from the weir, by methods to be detailed further on.

At the lower or experimental weirs the heads were measured for all experiments at the upper piezometer, 38 feet above the bulkhead, on which was placed the experimental weirs. This location was selected in order to insure the piezometers being well above the long back slopes of experiments Nos. 2, 3, 14, 15, and 16, or any other similar series which it might appear desirable to make.

Messrs. Fteley and Stearns remark that the only inaccuracy to come from measuring the heads more than 6 feet back will be that due to surface slope. We will now examine as to the possible effect of this in the present case.

For an observed head of 2.693 feet on the standard 16-foot weir

$$\frac{v^2}{2g}=0.013\text{ foot} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \tag{a}$$

and

$$1.33\left(\frac{v^2}{2g}\right)=0.017\text{ foot} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \tag{b}$$

The difference of 0.004 foot is far enough within the limit of accuracy to be negligible.

The corresponding observed head on the experimental weir, 6.56 feet in length, is 4.677 feet, giving

$$\frac{v^2}{2g}=0.198\text{ foot} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \tag{c}$$

also

$$1.33\left(\frac{v^2}{2g}\right)=0.270\text{ foot} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \tag{d}$$

The difference is 0.072 foot.

Taking the formula $v=C\sqrt{rs}$, in which $r=\frac{A}{P}$ and $s=\frac{h}{l}$, and with l equal to $(38-6)=32$ feet—the distance between where the piezometer should have been to comply with theoretical conditions for a standard weir and where it was actually set—and computing for h_s under a head of 4.677 feet on the experimental sharp-crested weir 6.56 feet in length, we find

$$h_s=0.061\text{ foot,}$$

which differs from the preceding difference of 0.072 foot by 0.011 foot. At slightly lower heads this difference disappears so rapidly as to become inappreciable, so far as effect on the coefficients of discharge is concerned.

It was concluded, therefore, that for the conditions of the present case

$$h_v = \frac{v^2}{2g}$$

gave more nearly the true correction than any other accepted formula.

Final coefficients of discharge for the several weirs have been obtained from the formula

$$C = m\sqrt{2g} = \frac{Q}{LH^{\frac{3}{2}}}$$

in which

Q = total flow over experimental weir, in cubic feet per second;
L = length of crest of experimental weir, in feet; and
H = final corrected head on experimental weir, in feet.

Q having been previously found, H was determined from the mean of the readings, for each period of experiment, of a piezometer connected to a horizontal tube placed flush with the bottom of the channel of approach. The correction for velocity of approach was then computed by the formulas just given, using appropriate values of p and h, Q being known from the previous work, as described.

The values of the coefficients M and C connected by the relation

$$C = M\sqrt{2g}$$

having been determined for the actual heads deduced from the experiments, the values of C so obtained were plotted and a mean curve drawn to best represent the observations. A new series of coefficients advancing by equal increments of H have been read from the curve so obtained, as shown by the tabulations of the experiments Nos. 1 to 21, on pages 678 to 690, following.

Values of Q = the discharge per lineal foot of crest have been computed by the formula

$$Q = CH^{\frac{3}{2}}$$

Having obtained the discharge over the sharp-crested experimental weir (6.53 feet in length) for heads up to 3.5 feet, the curve of discharge for the standard weir (16 feet in length) was extended to the height of 3 feet by using the coefficients obtained as just described. Plate 134 gives this curve, as well as the correction curve to be applied to observed heads for velocity in the channel of approach to the standard weir 16 feet in length. The additional experiments made on a sharp-crested weir at heads above 3.5 feet were then reduced in precisely the same manner as before, giving finally a series of coefficients of discharge over a sharp-crested weir with a range of heads from 0.746 foot to 4.874 feet. The discharge curve so obtained is exhibited on plate 135, where it has been extended to a head of 6 feet.

The method employed in reducing the experiments on weirs having crests of irregular profile is the same as for the sharp-crested weir, with the following exceptions:

In addition to the piezometric observations, direct observations of the head on each weir were taken on gauge boards situated above the standard and experimental weirs, respectively. The agreement between the heads so derived and those reduced from the mean piezometric readings is close in all cases, with the exception of the observed heads on the experimental weir in experiments Nos. 1, 2, 3, and 4. Without going into the detail, it may be stated that for these four experiments, which were the first made, the heads directly observed on the gauge boards are apparently the more reliable, and they have accordingly been used in reducing these four experiments.

Again, in experiments Nos. 1, 2, 3, and 4, no observations were taken on the middle piezometer at the standard 16-foot weir. In order to reduce the observed heads as actually taken on the upstream piezometer at this weir to equivalent heads on the middle piezometer, a correction has been applied, the value of which was obtained as follows: Plotting the difference between the readings of the upper and middle piezometers as ordinates for all experiments in which readings were taken on both, and using the observed heads on the upstream piezometer as abscissas, a mean curve has been drawn, from which the correction to be applied to any reading on the upstream piezometer can be read directly. This curve is shown on plate 136. The reason for using the readings of the middle in preference to those taken on the upstream piezometer at the standard 16-foot weir is that the former agree more closely on the whole with the readings of the gauge board; also the middle piezometer, which is only 10 feet distant from the bulkhead, on which the standard 16-foot weir was located, is more nearly at the proper distance from the weir than the upstream piezometer, which is 25 feet distant from the weir. Moreover, the upstream piezometer was situated so far back from the standard weir as to be evidently disturbed somewhat by the entrance velocity of the water in the leading channel.

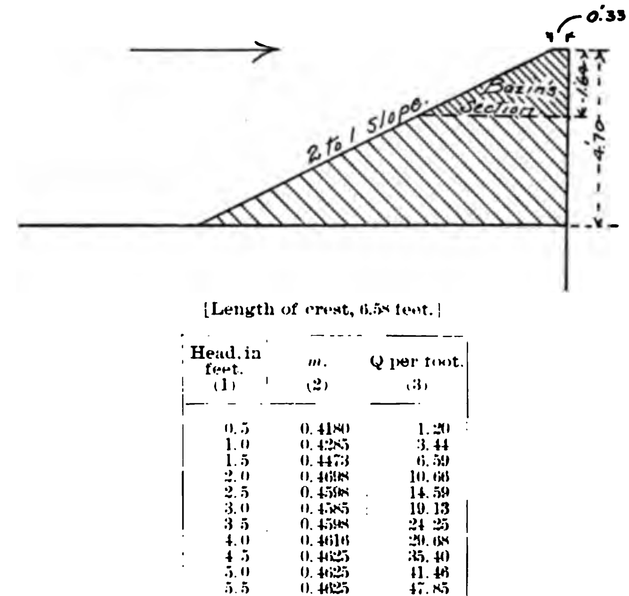
With the exception of experiments Nos. 18, 19, 20, and 21, the readings at the experimental weir were taken from a piezometer placed horizontally across the channel of approach at a height of about 8 inches above the bottom. In order to reduce the readings from this piezometer to the equivalent readings from piezometer placed flush with the bottom of the channel a correction curve has been deduced in the following manner: In experiments Nos. 18 and 19 observations were taken from both the flush piezometer and from one situated 8 inches above the bottom. Plotting the differences between the readings of these two piezometers corresponding to given heads on the standard weir as ordinates, and using the observed heads on the standard weir as abscissas, a mean curve has been drawn from which a correction to be applied in any case can be read directly. This curve is shown by plate 137.

In regard to the use of this correction curve it may be pointed out that the error resulting from the use of a piezometer placed otherwise than flush with the bottom or side of the channel is a function of the velocities in the channel of approach. Inasmuch as the discharging capacities of weirs of different sections vary greatly under the same heads, the velocity of approach at any given head will depend both upon the height P of the weir and on the coefficient of discharge for the particular head and section of weir considered. Unfortunately the data obtained were insufficient to enable the effect of these elements to be taken into consideration separately. Hence, the corrections obtained from the mean curve of plate 137 must be considered as approximate only. Some of the deviation of the experimental coefficients from the mean coefficient curves may undoubtedly be attributed to the uncertainty as to just the proper value of this correction.

On plate 138 we have included the coefficient curves finally fixed upon by the foregoing discussion for the experiments Nos. 1 to 19, inclusive. The coefficient curve for experiments Nos. 20 and 21 on the standard sharp-crested weir 6.53 feet in length is shown on plate 135. These curves are so self-explanatory as to render extended description unnecessary.

The following tabulations give the results of the Cornell University experiments. In column (1) of these tables we have the heads in feet, as read from the coefficient curves of plate 138, column (3) giving the discharge per linear foot of crest in cubic feet per second. Column (2) gives values of the coefficient *m*.

CORNELL UNIVERSITY EXPERIMENT NO. 1—BAZIN'S SERIES NO. 130—MAY 20, 1899.[1]



[Length of crest, 6.58 feet.]

Head, in feet. (1)	*m*. (2)	Q per foot. (3)
0.5	0.4180	1.20
1.0	0.4285	3.44
1.5	0.4473	6.59
2.0	0.4698	10.66
2.5	0.4598	14.59
3.0	0.4585	19.13
3.5	0.4598	24.25
4.0	0.4616	29.68
4.5	0.4625	35.40
5.0	0.4625	41.46
5.5	0.4625	47.85
6.0	0.4625	54.54

Number of experiments, 7.
Limiting heads, 1.19 feet and 4.97 feet.

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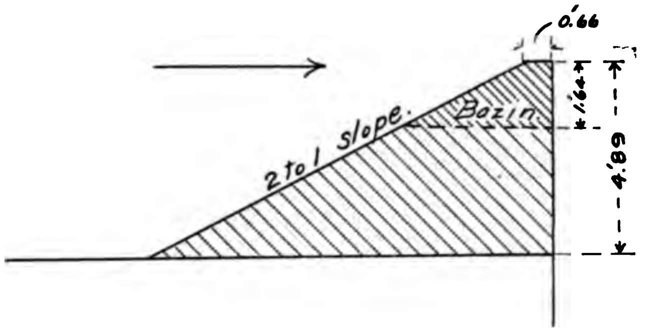
[1] For a considerable extension of these experiments see Trans. Am. Soc. C. E., Paper No. 884, On the Flow of Water Over Dams, Vol. XLIV, December, 1900.

CORNELL UNIVERSITY EXPERIMENT NO. 2—BAZIN'S SERIES, NO. 135—MAY 24, 1899.

[Length of crest, 6.58 feet.]

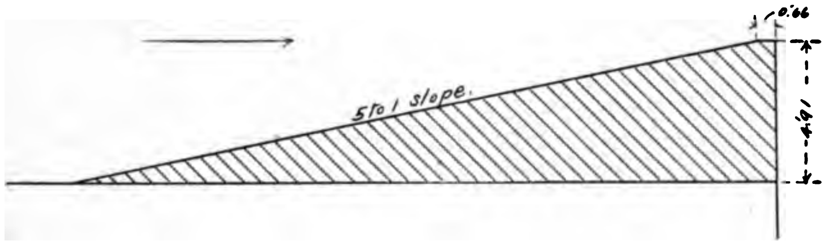


Head, in feet (1)	*m.* (2)	Q per foot. (3)
0.5	0.4012	1.15
1.0	0.4285	3.44
1.5	0.4474	6.59
2.0	0.4584	10.35
2.5	0.4598	14.59
3.0	0.4585	19.12
3.5	0.4598	24.15
4.0	0.4615	29.65
4.5	0.4625	35.40
5.0	0.4625	41.46
5.5	0.4625	47.84
6.0	0.4625	54.54

Number of experiments, 7.
Limiting heads, 0.341 foot and 5.05 feet.

CORNELL UNIVERSITY EXPERIMENT NO. 3—MAY 26, 1899.

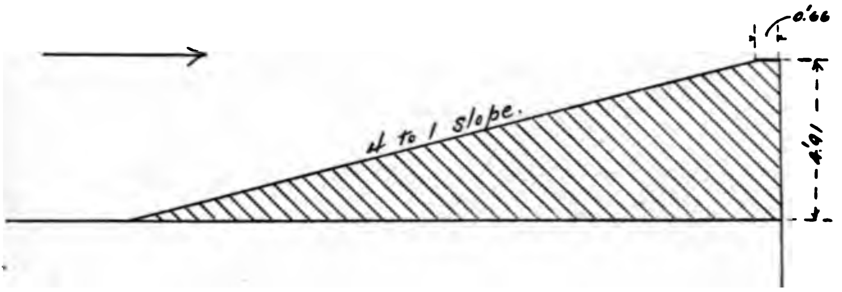
[Length of crest, 6.58 feet.]



Head, in feet. (1)	*m* (2)	Q per foot. (3)
0.5	0.412	1.18
1.0	0.415	3.33
1.5	0.416	6.13
2.0	0.418	9.49
2.5	0.420	13.32
3.0	0.421	17.55
3.5	0.422	22.18
4.0	0.422	27.12
4.5	0.422	32.34
5.0	0.422	37.88
5.5	0.422	43.71
6.0	0.422	49.81

Number of experiments, 3.
Limiting heads, 1.75 feet and 5.23 feet.

CORNELL UNIVERSITY EXPERIMENT NO. 4—MAY 26, 1899.

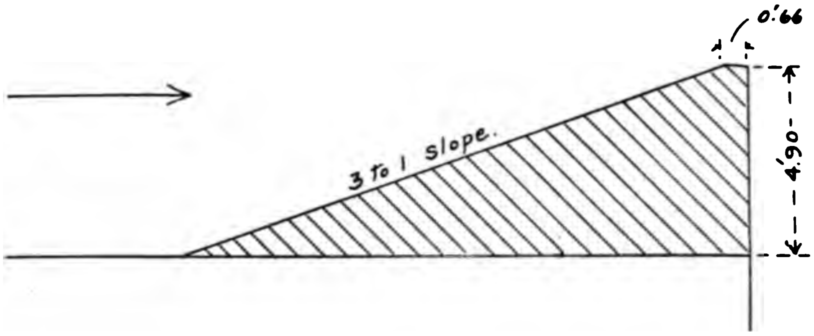


[Length of crest, 6.58 feet.]

Head, in feet. (1)	m. (2)	Q per foot. (3)
1.0	0.429	3.44
1.5	0.432	6.36
2.0	0.434	9.83
2.5	0.434	13.77
3.0	0.434	18.07
3.5	0.434	22.77
4.0	0.434	27.83
4.5	0.434	33.20
5.0	0.434	38.89
5.5	0.434	44.88
6.0	0.434	51.13

Number of experiments, 6.
Limiting heads, 0.917 foot and 5.11 feet.

CORNELL UNIVERSITY EXPERIMENT NO. 5—MAY 27, 1899.



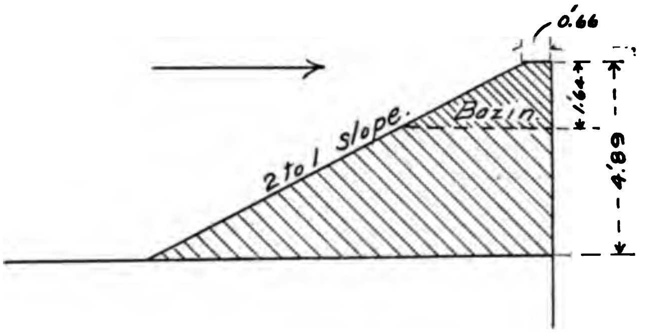
[Length of crest, 6.58 feet.]

Head, in feet. (1)	m. (2)	Q per foot. (3)
0.5	0.454	1.28
1.0	0.476	3.82
1.5	0.478	7.17
2.0	0.4596	10.42
2.5	0.4474	14.19
3.0	0.4425	18.45
3.5	0.4424	23.24
4.0	0.4424	28.40
4.5	0.4424	33.87
5.0	0.4424	39.68
5.5	0.4424	45.79
6.0	0.4424	52.16

Number of experiments, 5.
Limiting heads, 1.689 feet and 5.085 feet.

CORNELL UNIVERSITY EXPERIMENT NO. 2—BAZIN'S SERIES, NO. 135—MAY 24, 1899.

[Length of crest, 6.58 feet.]

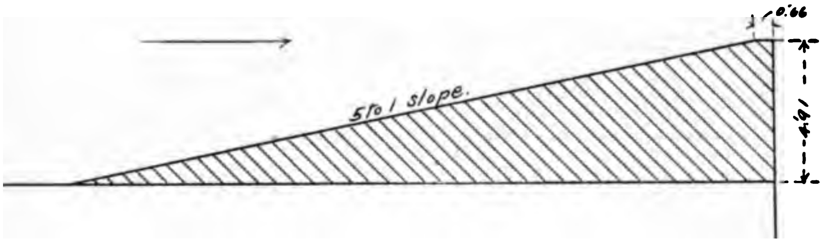


Head, in feet. (1)	m. (2)	Q per foot. (3)
0.5	0.4012	1.15
1.0	0.4285	3.44
1.5	0.4474	6.59
2.0	0.4564	10.35
2.5	0.4598	14.59
3.0	0.4585	19.12
3.5	0.4598	24 15
4.0	0.4615	29.65
4.5	0.4625	35.40
5.0	0.4625	41.46
5.5	0.4625	47.84
6.0	0.4625	54.54

Number of experiments, 7.
Limiting heads, 0.341 foot and 5.05 feet.

CORNELL UNIVERSITY EXPERIMENT NO. 3—MAY 26, 1899.

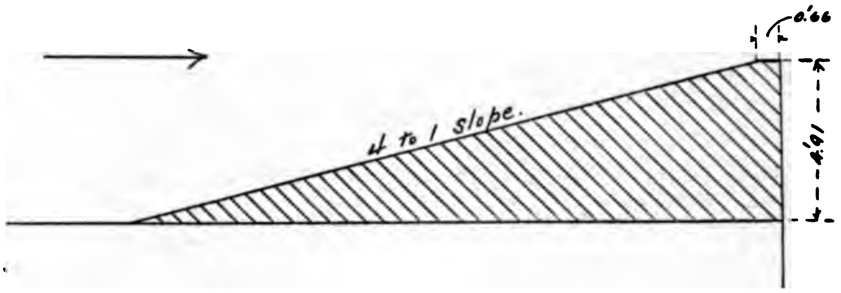
[Length of crest, 6.58 feet.]



Head, in feet. (1)	m (2)	Q per foot. (3)
0.5	0.412	1.18
1.0	0.415	3.33
1.5	0.416	6.13
2.0	0.418	9.49
2.5	0.420	13.32
3.0	0.421	17 55
3.5	0.422	22.18
4.0	0.422	27.12
4.5	0.422	32.34
5 0	0.422	37.88
5.5	0.422	43.71
6.0	0.422	49.81

Number of experiments, 3.
Limiting heads, 1.75 feet and 5.23 feet.

CORNELL UNIVERSITY EXPERIMENT NO. 4—MAY 26, 1899.

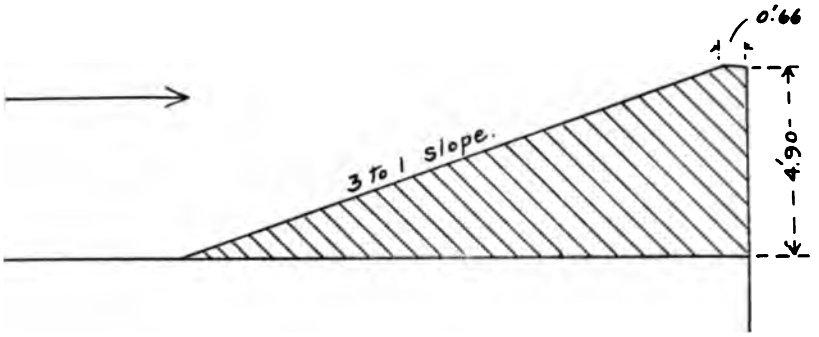


[Length of crest, 6.58 feet.]

Head, in feet. (1)	m. (2)	Q per foot. (3)
1.0	0.429	3.44
1.5	0.432	6.36
2.0	0.434	9.83
2.5	0.434	13.77
3.0	0.434	18.07
3.5	0.434	22.77
4.0	0.434	27.83
4.5	0.434	33.20
5.0	0.434	38.89
5.5	0.434	44.88
6.0	0.434	51.13

Number of experiments, 6.
Limiting heads, 0.917 foot and 5.11 feet

CORNELL UNIVERSITY EXPERIMENT NO. 5—MAY 27, 1899.

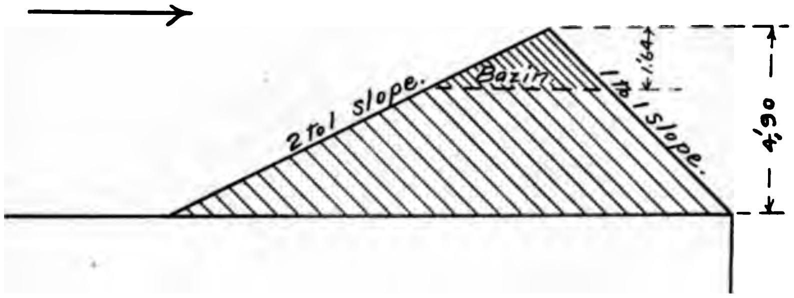


[Length of crest, 6.58 feet.]

Head, in feet. (1)	m. (2)	Q per foot. (3)
0.5	0.454	1.28
1.0	0.476	3.82
1.5	0.478	7.17
2.0	0.4598	10.42
2.5	0.4474	14.19
3.0	0.4425	18.45
3.5	0.4424	23.24
4.0	0.4424	28.40
4.5	0.4424	33.87
5.0	0.4424	39.68
5.5	0.4424	45.79
6.0	0.4424	52.16

Number of experiments, 5.
Limiting heads, 1.689 feet and 5.085 feet.

CORNELL UNIVERSITY EXPERIMENT NO. 6—BAZIN'S SERIES NO. 162—MAY 27, 1899.

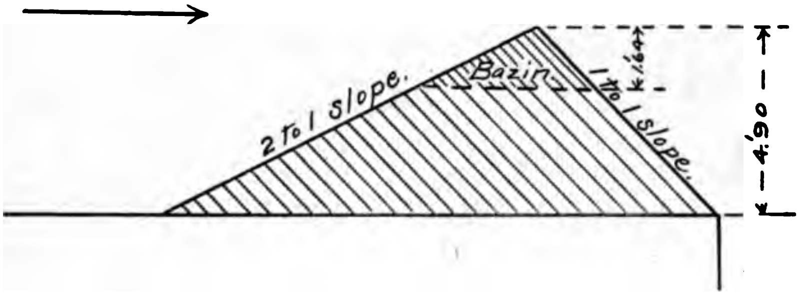


[Length of crest, 6.58 feet—From full line coefficient curve on plate 138.]

Head, in feet. (1)	*m*. (2)	Q per foot. (3)
0.5	0.5255	1.50
1.0	0.5288	4.24
1.5	0.5096	7.52
2.0	0.4949	11.22
2.5	0.4848	15.37
3.0	0.4773	19.90
3.5	0.4708	24.75
4.0	0.4661	29.92
4.5	0.4620	35.40
5.0	0.4585	41.14
5.5	0.4548	47.08
6.0	0.4525	53.35

Number of experiments, 5.
Limiting heads, 1.685 feet and 4.745 feet.

CORNELL UNIVERSITY EXPERIMENT NO. 6—BAZIN'S SERIES NO. 162—MAY 27, 1899.

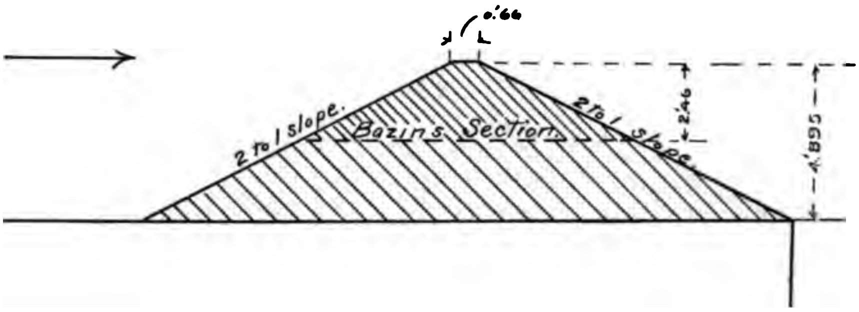


[Length of crest, 6.58 feet—From full line coefficient curve on plate 138.]

Coefficients from dotted curve on coefficient diagram, showing effect of a change of position of the mean coefficient curve.

Head, in feet. (1)	*m*. (2)	Q per foot. (3)
0.5	0.525	1.50
1.0	0.529	4.24
1.5	0.505	7.43
2.0	0.486	11.02
2.5	0.470	15.10
3.0	0.467	19.48
3.5	0.464	24.35
4.0	0.461	29.60
4.5	0.459	35.11
5.0	0.453	41.03
5.5	0.455	47.08
6.0	0.453	53.35

CORNELL UNIVERSITY EXPERIMENT NO. 7—BAZIN'S SERIES NO. 178—MAY 29, 1899.

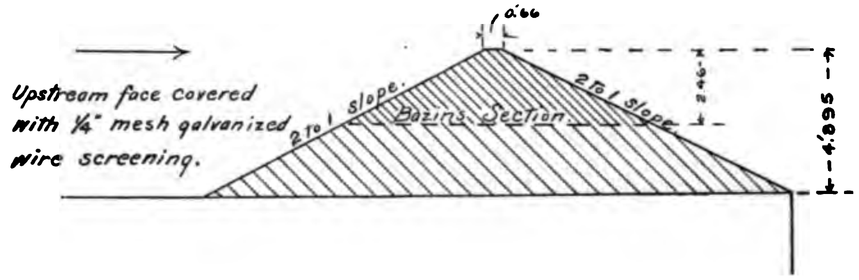


[Length of crest, 6.58 feet.]

Head, in feet. (1)	*m*. (2)	Q per foot. (3)
0.5	0.394	1.12
1.0	0.428	3.44
1.5	0.444	6.54
2.0	0.452	10.28
2.5	0.457	14.49
3.0	0.457	19.08
3.5	0.458	24.05
4.0	0.459	29.45
4.5	0.458	35.07
5.0	0.457	40.98
5.5	0.456	47.17
6.0	0.455	53.72

Number of experiments, 4.
Limiting heads, 2.499 feet and 4.988 feet.

CORNELL UNIVERSITY EXPERIMENT NO. 7—BAZIN'S SERIES NO. 178—MAY 30, 1899

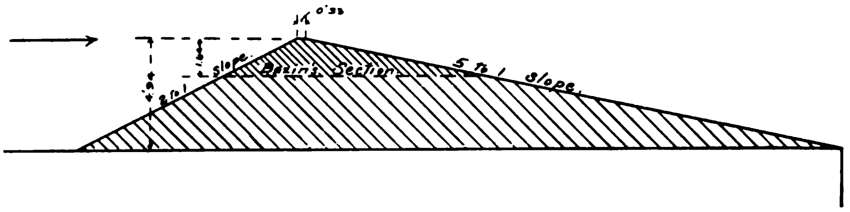

0.'66
Upstream face covered with ¼" mesh galvanized wire screening.
2 to 1 slope.
Bazin's Section
2 to 1 slope.
2.46
4.'895

[Length of crest, 6.58 feet.]

Head, in feet. (1)	*m*. (2)	Q per foot. (3)
0.5	0.391	1.11
1.0	0.425	3.42
1.5	0.442	6.51
2.0	0.450	10.21
2.5	0.453	14.39
3.0	0.456	18.99
3.5	0.457	24.00
4.0	0.456	29.30
4.5	0.455	34.85
5.0	0.454	40.74
5.5	0.453	46.88
6.0	0.452	53.36

Number of experiments, 5.
Limiting heads, 1.657 feet and 5.011 feet.

CORNELL UNIVERSITY EXPERIMENT NO. 9—BAZIN'S SERIES NO. 173—MAY 31, 1899.

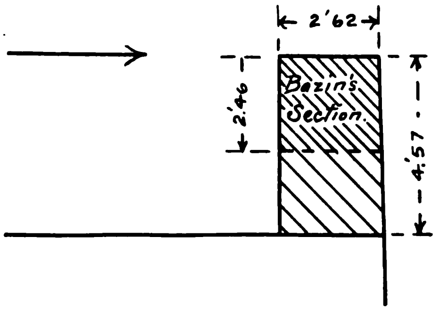


[Length of crest, 6.58 feet.]

Head, in feet. (1)	m. (2)	Q per foot. (3)
0.5	0.4112	1.17
1.0	0.4450	3.57
1.5	0.4480	6.60
2.0	0.4374	9.92
2.5	0.4355	13.83
3.0	0.4356	18.16
3.5	0.4375	22.97
4.0	0.4410	28.30
4.5	0.4436	33.98
5.0	0.4446	39.87
5.5	0.4446	46.01
6.0	0.4446	52.44

Number of experiments, 4.
Limiting heads, 1.677 feet and 4.842 feet.

CORNELL UNIVERSITY EXPERIMENT NO. 10—BAZIN'S SERIES NO. 114—JUNE 1, 1899.

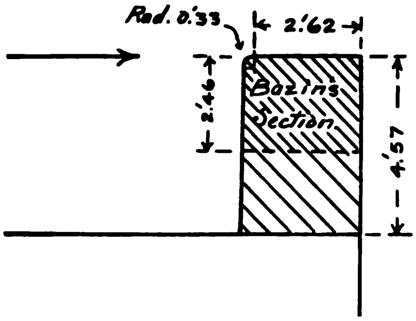


[Length of crest, 6.58 feet.]

Head, in feet. (1)	m. (2)	Q per foot. (3)
0.5	0.324	0.93
1.0	0.333	2.67
1.5	0.343	5.04
2.0	0.354	8.02
2.5	0.365	11.58
3.0	0.376	15.66
3.5	0.388	20.37
4.0	0.400	25.67
4.5	0.411	31.45
5.0	0.422	37.86
5.5	0.426	44.10
6.0	0.435	51.15

Number of experiments, 5.
Limiting heads, 2.038 feet and 5.324 feet.

CORNELL UNIVERSITY EXPERIMENT NO. 11—BRAZIN'S SEIRES—NO. 116 JUNE 1, 1899.

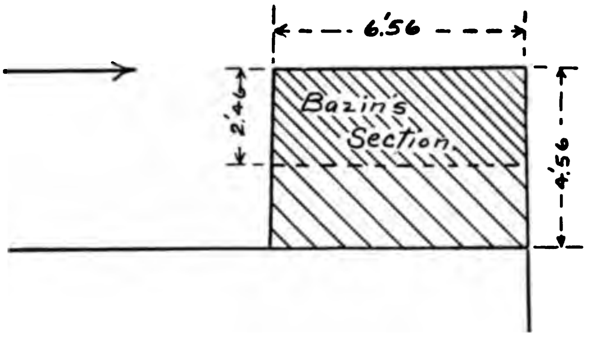


[Length of crest, 6.58 feet.]

Head, in feet. (1)	*m*. (2)	Q per foot. (3)
0.5	0.369	1.06
1.0	0.375	3.01
1.5	0.378	5.57
2.0	0.384	8.72
2.5	0.388	12.31
3.0	0.405	16.89
3.5	0.414	21.77
4.0	0.422	27.08
4.5	0.428	32.77
5.0	0.433	38.84
5.5	0.437	45.27
6.0	0.442	52.70

Number of experiments, 5. Limiting heads, 1.949 feet and 5.208 feet.

CORNELL UNIVERSITY EXPERIMENT NO. 12—BAZIN'S SERIES NO. 115—JUNE 2, 1899.

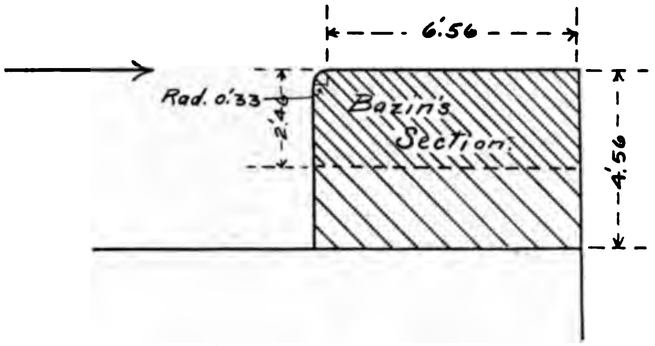


[Length of crest, 6.58 feet.]

Head, in feet. (1)	*m*. (2)	Q per foot. (3)
0.5	0.3117	0.90
1.0	0.3238	2.60
1.5	0.3170	4.67
2.0	0.3005	7.04
2.5	0.3088	9.80
3.0	0.3133	13.06
3.5	0.3193	16.78
4.0	0.3251	20.88
4.5	0.3307	25.35
5.0	0.3364	30.18
5.5	0.3414	35.33
6.0	0.3437	40.55

Number of experiments, 4. Limiting heads, 2.175 feet and 5.102 feet.

CORNELL UNIVERSITY EXPERIMENT NO. 13—BAZIN'S SERIES NO. 117—JUNE 2, 1899.

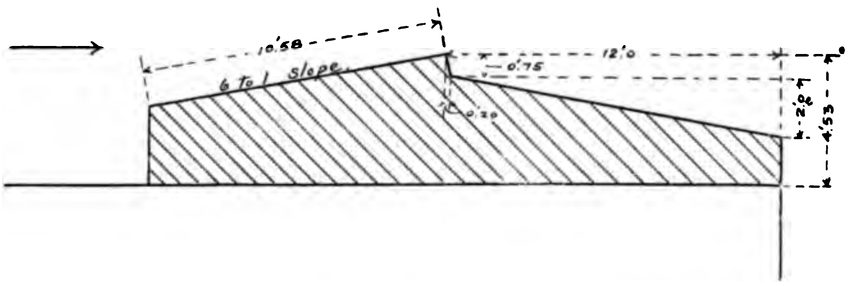


[Length of crest, 6.58 feet.]

Head, in feet. (1)	m. (2)	Q per foot. (3)
0.5	0.338	0.98
1.0	0.352	2.83
1.5	0.354	5.22
2.0	0.354	8.05
2.5	0.355	11.26
3.0	0.356	14.85
3.5	0.358	18.83
4.0	0.360	23.17
4.5	0.363	27.84
5.0	0.367	32.91
5.5	0.369	38.22
6.0	0.370	43.70

Number of experiments, 5.
Limiting heads, 1.016 feet and 4.830 feet.

CORNELL UNIVERSITY EXPERIMENT NO. 14—REXFORD FLATS DAM—JUNE 3, 1899.

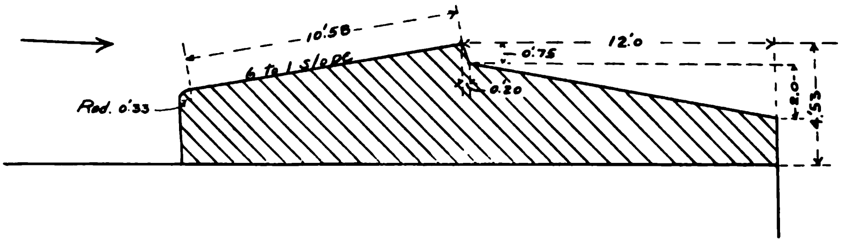


[Length of crest, 6.58 feet.]

Head, in feet. (1)	m. (2)	Q per foot. (3)
0.5	0.355	1.02
1.0	0.377	3.02
1.5	0.394	5.80
2.0	0.403	9.15
2.5	0.406	12.86
3.0	0.406	16.90
3.5	0.405	21.27
4.0	0.405	26.00
4.5	0.404	30.97
5.0	0.404	36.22
5.5	0.403	41.76
6.0	0.403	47.56

Number of experiments, 6.
Limiting heads, 0.924 foot and 5.418 feet.

CORNELL UNIVERSITY EXPERIMENT NO. 15-REXFORD FLATS DAM, WITH UPSTREAM EDGE OF CREST ROUNDED TO A RADIUS OF 0.328 FOOT—JUNE 3, 1899.

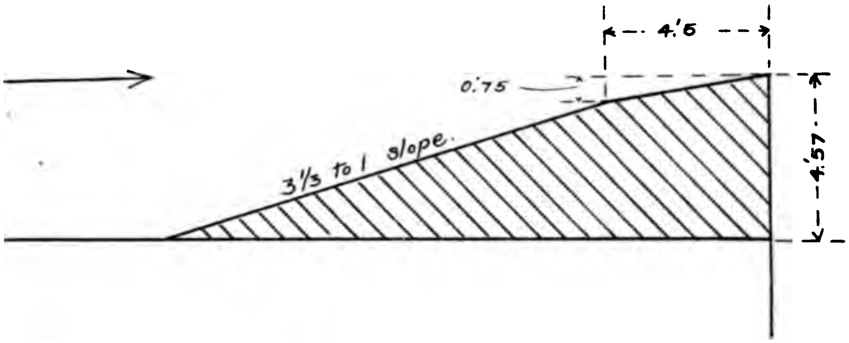


[Length of crest, 6.58 feet.]

Head, in feet. (1)	*m*. (2)	Q per foot. (3)
0.5	0.371	1.06
1.0	0.389	3.12
1.5	0.400	5.90
2.0	0.408	9.25
2.5	0.412	13.07
3.0	0.415	17.32
3.5	0.416	21.86
4.0	0.417	26.65
4.5	0.414	31.72
5.0	0.413	37.15
5.5	0.412	42.65
6.0	0.411	48.48

Number of experiments, 4.
Limiting heads, 1.786 feet and 4.439 feet.

CORNELL UNIVERSITY EXPERIMENT NO. 16—LITTLE FALLS DAM, SECTION NO. 1—JUNE 5, 1899.

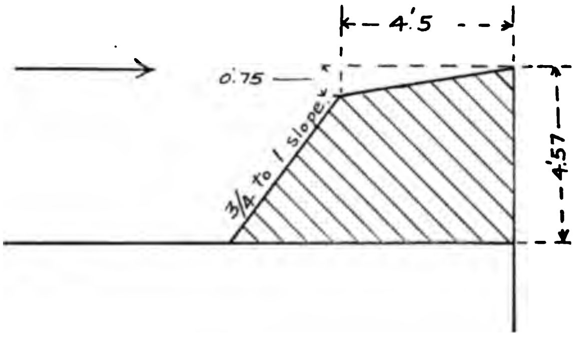


[Length of crest, 6.58 feet.]

Head, in feet. (1)	*m*. (2)	Q per foot. (3)
0.5	....	....
1.0	0.432	3.47
1.5	0.428	6.30
2.0	0.424	9.62
2.5	0.421	13.36
3.0	0.422	17.58
3.5	0.425	22.32
4.0	0.428	27.48
4.5	0.431	33.01
5.0	0.433	38.87
5.5	0.435	45.00
6.0	0.436	51.44

Number of experiments, 4.
Limiting heads, 1.735 feet and 4.339 feet.

CORNELL UNIVERSITY EXPERIMENT NO. 17—LITTLE FALLS DAM, SECTION NO. 2—JUNE 5, 1899.

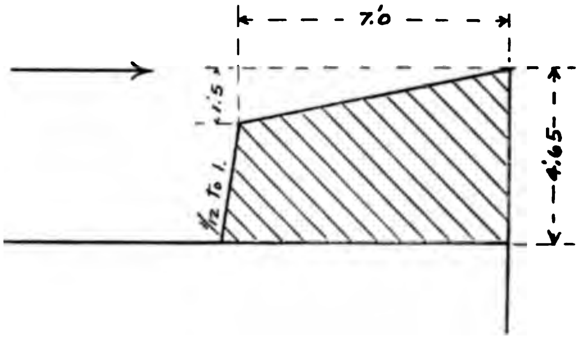


[Length of crest, 6.58 feet.]

Head, in feet. (1)	m. (2)	Q per foot. (3)
0.5		
1.0	0.415	3.33
1.5	0.425	6.25
2.0	0.430	9.76
2.5	0.432	13 70
3.0	0.432	18.03
3.5	0.432	22.66
4.0	0.432	27.75
4.5	0.432	33.05
5.0	0.432	38.75
5.5	0.432	44.68
6.0	0.432	50.90

Number of experiments, 5.
Limiting heads, 1.067 feet and 4.336 feet.

CORNELL UNIVERSITY EXPERIMENT NO. 18—SECTION OF SPILLWAY OF INDIAN LAKE DAM—JUNE 6, 1899.

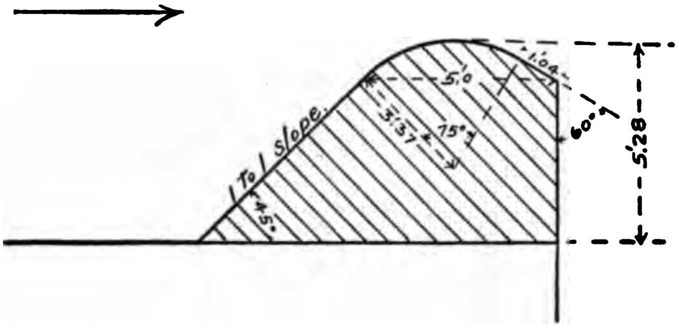


[Length of crest, 6.58 feet.]

Head, in feet. (1)	m. (2)	Q per foot. (3)
0.5	....	....
1.0	0.476	3.82
1.5	0.460	6.78
2.0	0.458	10.38
2.5	0.435	13.79
3.0	0.429	17.89
3.5	0.427	22.45
4.0	0.428	27.46
4.5	0.429	32.81
5.0	0.429	38.45
5.5	0.429	44.37
6.0	0.429	50.55

Number of experiments, 5.
Limiting heads, 1.277 feet and 5.180 feet.

CORNELL UNIVERSITY EXPERIMENT NO. 19—SECTION FOR SUBMERGED WEIR—JUNE 7, 1899.

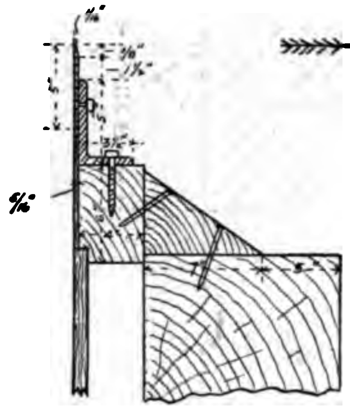


[Length of crest, 6.58 feet.]

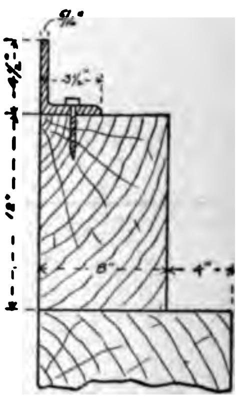
Head, in feet. (1)	m. (2)	Q per foot. (3)
0.5	0.367	1.04
1.0	0.394	3.17
1.5	0.412	6.06
2.0	0.430	9.77
2.5	0.439	13.91
3.0	0.443	18.48
3.5	0.447	23.46
4.0	0.450	28.88
4.5	0.452	34.63
5.0	0.455	40.80
5.5	0.457	47.28
6.0	0.458	54.02

Number of experiments, 8.
Limiting heads, 0.887 foot and 4.913 feet.

CORNELL UNIVERSITY EXPERIMENTS NOS. 20 AND 21—FLOW OVER A STANDARD SHARP-CRESTED WEIR WITH FREE OVERFALL—FROM CURVE OF DISCHARGE FOR A LENGTH OF 1 FOOT—JUNE 10 AND 12, 1899.



Lower Weir, length, 6.53.



Upper Weir, length, 16.0.

[Length of crest, 6.53 feet.]

Head, in feet. (1)	*m.* (2)	Q per foot. (3)	Head, in feet. (1)	*m.* (2)	Q per foot. (3)
0.0	0.0	0.0	3.1	0.4095	17.86
0.1	0.4286	0.17	3.2	0.4095	18.75
0.2	0.4268	0.35	3.3	0.4095	19.68
0.3	0.4258	0.60	3.4	0.4098	20.60
0.4	0.4242	0.87	3.5	0.4099	21.54
0.5	0.4230	1.20	3.6	0.4102	22.50
0.6	0.4215	1.56	3.7	0.4105	23.45
0.7	0.4204	1.95	3.8	0.4107	24.42
0.8	0.4194	2.37	3.9	0.4109	25.40
0.9	0.4186	2.86	4.0	0.4112	26.40
1.0	0.4174	3.35	4.1	0.4113	27.37
1.1	0.4166	3.86	4.2	0.4116	28.40
1.2	0.4158	4.43	4.3	0.4118	29.42
1.3	0.4150	4.97	4.4	0.4122	30.52
1.4	0.4145	5.52	4.5	0.4125	31.62
1.5	0.4136	6.10	4.6	0.4126	32.72
1.6	0.4129	6.70	4.7	0.4129	33.80
1.7	0.4122	7.32	4.8	0.4130	34.90
1.8	0.4115	7.95	4.9	0.4131	35.97
1.9	0.4109	8.60	5.0	0.4133	37.09
2.0	0.4106	9.32	5.1	0.4133	38.20
2.1	0.4100	10.05	5.2	0.4133	39.32
2.2	0.4097	10.77	5.3	0.4134	40.47
2.3	0.4095	11.56	5.4	0.4134	41.63
2.4	0.4094	12.30	5.5	0.4135	42.81
2.5	0.4094	13.03	5.6	0.4135	44.00
2.6	0.4094	13.80	5.7	0.4135	45.20
2.7	0.4094	14.55	5.8	0.4136	46.50
2.8	0.4094	15.35	5.9	0.4136	47.74
2.9	0.4094	16.17	6.0	0.4136	48.81
3.0	0.4094	17.03			

Number of experiments, 13.
Limiting heads, 0.746 foot and 4.874 feet.

Photographic plates A and B show the lower end of the lower channel as it appeared on the afternoon of June 3, 1899, while the experiments on the Rexford Flats section were in progress.

It is not the author's intention to extensively review the results of the Cornell University experiments at this time, any further than to point out that they were, in the fullest sense, practical experiments.

PLATE A.

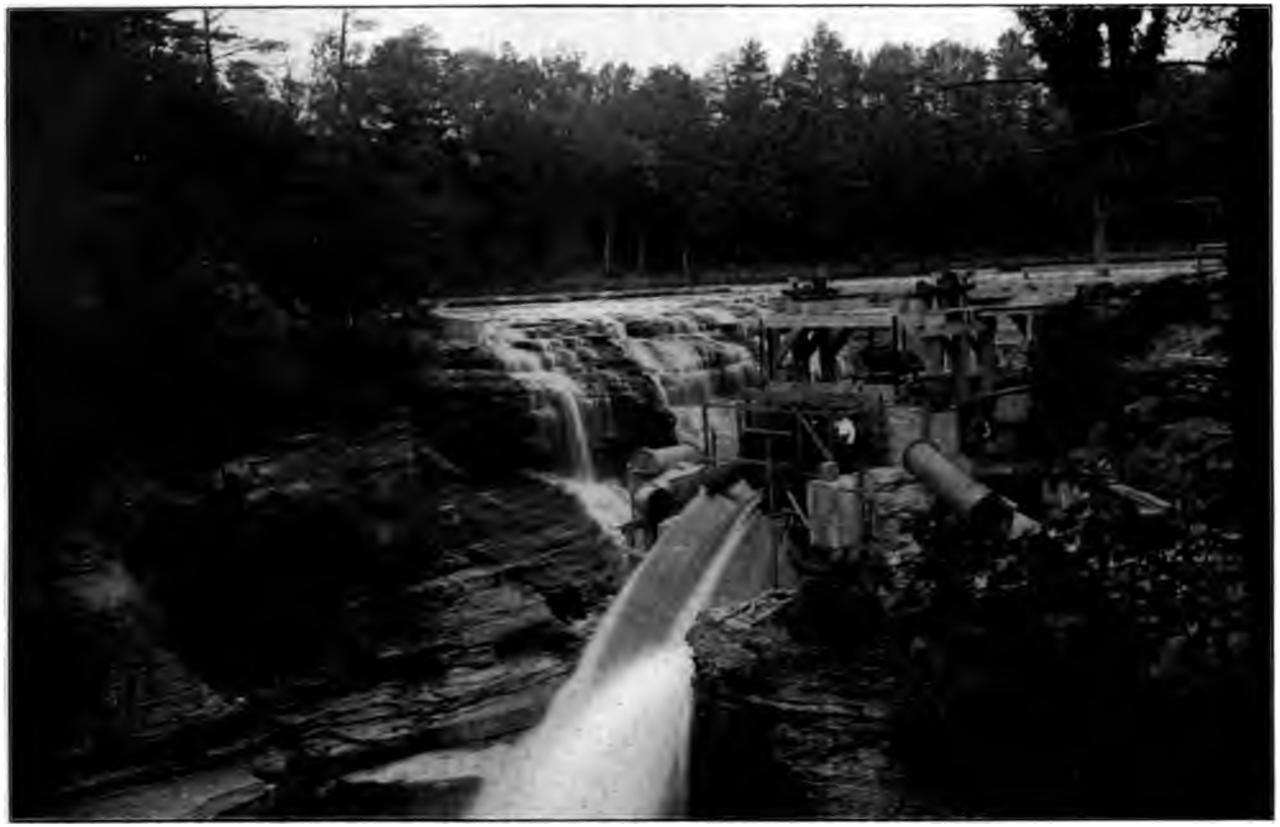


Photo by G. W. R.

EXPERIMENT ON REXFORD FLATS DAM AT CORNELL UNIVERSITY. JUNE 3, 1899

PLATE B.

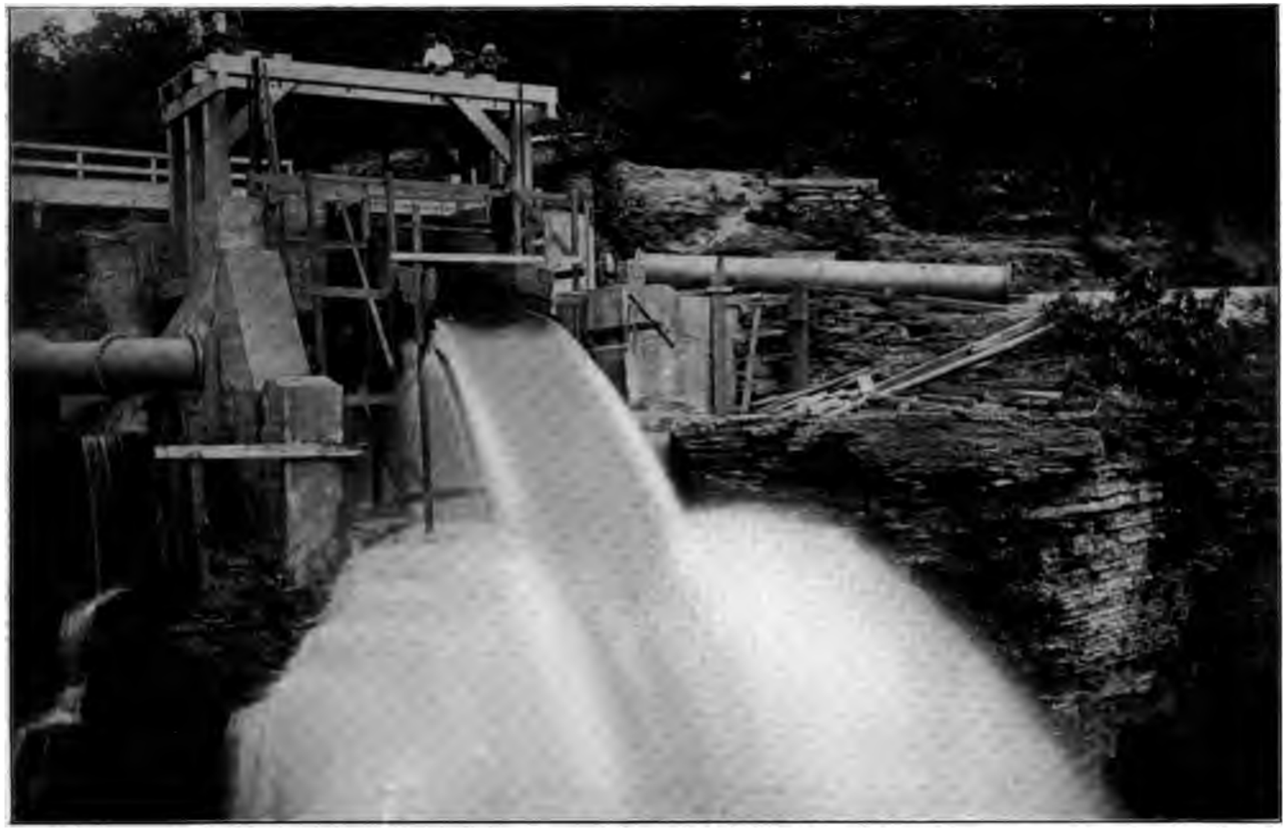


Photo by G. W. R.

EXPERIMENT ON REXFORD FLATS DAM AT CORNELL UNIVERSITY JUNE 3. 1899.

Every attempt was made to duplicate dams as found in actual practice, the author's view being that such experiments are only of moderate value when made with reference to theoretical conditions purely and without reference to practice. A salient object lesson on this point is presented by the revised curves on plates 107 to 126, inclusive.

In experiments Nos. 7 and 8 an attempt was made to gain some idea of the effect of a rough surface on dams. Experiment No. 7 was of the usual form, with the crest constructed of planed matched pine, as already described, while in experiment No. 8 the upstream face of the crest was covered with one-quarter inch mesh galvanized wire screen. A comparison of these two experiments is very instructive. The upper limiting head of No. 7 was 4.996 feet and of experiment No. 8 5.011 feet. For 5-foot head, as determined from the curves, we have for experiment No. 7 a discharge of 40.98 cubic feet per second per linear foot of crest, while for experiment No. 8, 5-foot head gives a discharge of 40.74 feet per second per linear foot of crest. Similar comparisons at other heads show the effect of the wire screen to have been but slight. The result of this experiment was such as to lead to the conclusion that very little difference would be experienced in the flow over a dam after the first few months, during which time the planking, under the smoothing effect of silt in the flowing water, etc., may be expected to come substantially to the hydraulic condition of planed boards. Accordingly, as the time was limited for completing the work, no further determinations were made on this line.

It is recognized, however, that but for the limitation of time set by your Board it would have been very desirable to have experimented somewhat further on a number of additional forms of weirs, and it is to be hoped, in view of the vast practical importance of an accurate knowledge of flows over dams, that the Cornell University authorities will carry these experiments considerably further, keeping especially well within the limits of actual practice in the United States.

Experiment No. 6 may be also briefly referred to. On referring to the coefficient curve of this experiment, plate 138, it will be seen that two coefficient curves have been drawn. The first reduction of experiment No. 6 has been made on the basis of the coefficients derived from the full-line coefficient curve on plate 138, while the second reduction is from the coefficients from dotted curve in the coefficient diagram. The dotted curve shows that relatively a considerable change of position of the mean coefficient curve may be made without very greatly affecting the results. This fact may, it appears, be taken to indicate the essential accuracy of the values of the coefficient C in the foregoing tables.

Table No. 20.—*Record of precipitation at Adams for certain water years as indicated from 1872 to 1898, inclusive.*

Month.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1890.
December	*a*3.32	5.12	2.95	3.03	2.80	......	1.70	......
January	4.78	5.18	7.73	4.33	4.29	......	......	......
February	3.29	1.65	3.58	2.17	3.70	......	0.60	......
March	1.97	8.10	3.65	2.69	5.43	4.92	......	......
April	1.79	2.60	3.42	1.12	3.41	1.76	......	......
May	2.74	1.52	2.24	4.14	2.12	......	......	......
Total	17.89	24.17	23.57	17.48	21.75	......	......	......
June	3.59	4.19	5.00	2.17	*b*1.80	3.54	......	2.38
July	2.44	3.94	6.01	1.24	4.50	......	......	4.02
August	2.07	1.40	1.80	3.13	1.00	1.95	......	......
Total	8.10	9.53	12.81	6.54	7.30	......	......	......
September	3.40	3.65	3.84	3.52	2.38	1.70	......	7.28
October	5.77	7.12	4.08	3.80	2.84	1.88	......	4.88
November	3.98	11.16	4.10	2.98	2.57	3.46	......	2.72
Total	13.15	21.93	12.02	10.30	7.79	7.02	......	14.68
Yearly total	39.14	55.63	48.40	34.32	36.84	......	......	......

Month.	1891.	1892.	1893.	1894.	1896.	1897.	1898.	Mean.
December	2.03	3.63	3.61	......	......	1.65	3.95	......
January	1.94	5.44	1.85	......	......	1.53	3.63	......
February	1.28	2.21	3.37	......	......	1.41	1.23	......
March	1.37	2.69	1.47	......	......	3.03	1.15	......
April	1.46	0.98	2.41	......	......	3.30	2.28	......
May	0.83	5.32	......	......	1.90	*b*3.99	2.84	......
Total	8.85	20.27	......	......	......	14.91	15.08	......
June	1.32	5.81	......	......	1.88	2.05	2.15	......
July	5.59	5.18	......	2.52	4.33	8.22	*c*1.19	......
August	3.63	9.31	......	0.51	2.60	3.54	4.23	......
Total	10.54	20.30	......	......	8.81	13.81	7.57	......
September	3.06	5.37	......	5.96	3.66	0.78	2.92	......
October	2.24	2.10	......	8.34	1.77	0.42	6.43	......
November	3.78	6.16	......	......	2.89	3.73	3.14	......
Total	9.08	13.63	......	......	8.32	4.93	12.49	......
Yearly total	28.47	54.20	......	......	......	33.65	35.14	40.64

a Mean of—

Depauville	4.28
Sacketts Harbor	1.98
Pierpont Manor	3.34
Port Ontario	3.69
	4)13.29
	3.32

b Sacketts Harbor record.

c Mean of—

Sacketts Harbor	0.60
Palermo	1.60
Canton	1.96
Lowville	0.60
	4)4.76
	1.19

TABLE NO. 21.—*Record of precipitation at Addison for the water years 1891 to 1898, inclusive.*

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	3.66	2.96	0.48	1.90	2.93	2.92	0.88	1.91	....
January	1.84	2.97	1.64	1.94	3.11	1.47	1.54	3.91	....
February	2.89	1.58	2.27	1.89	1.12	3.18	0.76	1.80	....
March	2.12	3.68	2.62	1.06	0.88	3.05	2.29	2.30	....
April	1.44	0.94	3.50	6.60	1.31	1.07	2.41	2.51	....
May	0.32	5.85	7.87	9.70	2.11	4.50	4.26	4.12	....
Total	12.27	17.98	18.38	23.09	11.46	16.19	12.14	16.55	....
June	2.05	3.18	3.04	1.82	4.15	5.78	2.56	3.67	....
July	2.91	4.94	2.37	2.06	2.02	4.45	4.52	2.16	....
August	4.24	3.62	3.69	1.44	2.82	0.77	2.05	2.92	....
Total	9.20	11.74	9.10	5.32	8.99	11.00	9.13	8.75	....
September	0.49	0.91	2.34	5.62	1.22	3.67	2.90	1.31	....
October	2.94	1.50	2.89	4.03	0.80	5.73	0.94	5.99	....
November	1.64	3.46	1.24	1.42	2.44	0.83	3.10	2.13	....
Total	5.07	5.87	6.47	11.07	4.46	10.23	6.94	9.43	....
Yearly total	26.54	35.59	33.95	39.48	24.91	37.42	28.21	34.73	32.60

TABLE NO. 22.—*Record of precipitation at Albany for the water years 1826 to 1898, inclusive.*

Month.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.
December	[a] 2.70	1.27	3.91	0.24	2.44	3.95	1.57	3.34	1.86	3.59	1.19	3.91	2.63	0.95
January	2.43	5.40	2.25	4.56	1.76	1.88	4.21	2.63	1.35	4.64	7.30	2.25	2.25	2.17
February	1.36	3.07	2.53	3.26	1.41	4.17	3.12	2.56	2.04	1.79	4.39	2.77	2.20	1.57
March	3.81	2.38	1.94	2.78	4.86	2.38	2.59	1.62	1.60	2.60	1.70	3.47	2.09	1.52
April	1.77	4.66	2.52	4.77	2.37	4.59	2.90	1.33	2.35	4.54	2.30	1.63	1.53	4.75
May	0.76	3.43	4.48	2.68	4.63	2.88	2.69	8.47	3.70	2.71	3.86	7.34	7.45	3.83
Total	12.83	20.21	17.63	18.29	17.47	19.85	17.08	19.95	12.90	19.87	20.74	21.37	18.15	14.79
June	6.22	3.75	2.87	3.90	7.58	4.04	3.57	2.36	2.32	6.48	5.67	5.06	7.60	5.12
July	5.33	5.43	5.40	3.22	2.37	4.32	4.28	4.48	5.25	5.39	2.43	4.38	1.72	5.77
August	2.46	4.69	0.88	1.46	1.55	3.25	7.51	3.36	2.77	5.34	2.25	3.96	4.91	1.24
Total	14.01	13.87	9.15	8.58	11.50	11.61	15.36	10.20	10.34	17.21	10.35	13.40	14.23	12.13
September	3.58	5.67	8.08	2.73	0.93	3.93	2.76	3.14	2.34	1.28	3.49	1.95	4.46	2.75
October	2.37	4.65	1.56	2.41	3.15	4.82	4.20	7.50	3.77	2.20	3.99	3.59	3.22	1.35
November	1.56	2.76	4.91	3.86	7.29	1.71	3.28	2.43	1.37	2.26	3.31	2.14	3.55	2.95
Total	7.51	13.08	14.55	9.00	11.37	10.46	10.24	13.07	7.48	5.74	10.79	7.68	11.33	7.05
Yearly total	34.35	47.16	41.33	35.87	40.34	41.92	42.68	43.22	30.72	42.82	41.88	42.45	43.71	33.97

Month.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.
December	5.09	2.95	4.14	5.21	2.36	3.50	1.19	2.96	4.31	5.24	2.11	4.41	2.29	2.80
January	2.16	4.19	1.15	2.13	1.35	4.64	3.03	2.54	2.07	0.76	2.81	0.78	2.16	2.09
February	2.44	2.12	3.21	3.21	2.04	1.79	3.72	3.80	2.37	1.25	2.16	4.38	1.46	3.68
March	3.99	3.15	2.69	7.37	1.60	2.60	3.34	4.39	2.78	2.86	1.96	0.94	3.13	2.35
April	5.23	3.75	4.90	4.25	2.35	4.54	0.74	2.79	1.08	0.75	3.76	4.14	3.85	3.80
May	5.28	2.24	1.44	2.07	3.70	2.71	3.45	2.25	8.11	5.40	6.01	2.61	2.64	7.16
Total	21.19	18.40	17.53	24.24	13.40	19.87	15.47	18.73	20.72	16.26	18.81	17.26	15.53	21.88
June	3.47	2.10	4.44	5.54	2.32	6.48	3.84	5.06	4.72	4.45	5.72	4.57	1.71	3.48
July	3.40	1.56	3.42	4.42	5.25	5.39	5.58	5.47	7.92	0.70	8.57	3.48	3.36	3.31
August	4.77	4.27	4.15	6.05	2.77	5.34	2.07	1.94	3.79	4.83	2.50	2.17	2.60	5.12
Total	11.64	7.93	12.01	16.01	10.34	17.21	11.49	12.47	16.43	9.98	16.79	10.22	7.67	11.91
September	5.76	5.65	6.40	2.19	2.34	1.28	2.22	3.56	3.22	1.06	6.56	1.27	1.50	7.67
October	4.81	1.34	4.22	5.72	3.77	2.22	3.53	3.08	4.31	8.04	4.31	2.93	2.38	2.65
November	3.13	3.34	4.76	3.04	1.37	2.26	5.37	2.19	2.61	4.51	2.20	5.10	4.20	3.33
Total	13.70	10.33	15.38	10.95	7.48	5.76	11.12	8.83	10.14	13.61	13.07	9.30	8.08	13.65
Yearly total	46.53	36.66	44.92	51.20	31.22	42.84	38.08	40.03	47.29	39.85	48.67	36.78	31.28	47.44

[a] Mean of seventy two years.

TABLE NO. 22.—*Record of precipitation at Albany for the water years 1826 to 1898, inclusive*—Continued.

Month.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	1861.	1862.	1863.	1864.	1865.	1866.	1867.
December	1.15	1.84	3.82	3.50	3.04	2.32	2.14	2.17	1.50	1.33	3.64	3.45	2.04	3.56
January	2.62	3.29	1.10	2.08	2.32	1.90	0.08	3.49	5.24	4.81	1.49	2.46	1.11	1.55
February	2.95	1.09	0.36	2.18	1.15	1.94	1.50	2.28	2.06	2.62	0.75	1.94	2.49	2.48
March	2.43	0.54	1.83	1.25	1.99	1.79	0.60	4.11	3.05	3.65	2.21	4.48	1.32	2.43
April	6.82	2.65	1.48	7.00	2.42	2.72	1.18	0.86	1.96	1.48	2.71	2.48	1.46	2.68
May	1.97	1.83	5.94	4.45	3.49	1.74	1.68	3.50	1.16	4.76	2.57	5.39	2.17	6.28
Total	17.95	11.24	14.53	20.46	14.41	12.41	7.18	16.41	14.97	18.65	13.37	20.20	10.59	18.98
June	2.96	6.84	3.62	4.91	3.31	5.21	3.48	1.46	8.70	1.37	0.80	3.04	4.51	4.57
July	3.35	3.95	1.33	5.45	6.94	3.17	4.55	6.04	3.62	7.83	1.48	3.70	4.18	3.18
August	0.62	3.75	10.14	3.74	2.90	3.19	6.09	4.15	2.84	3.60	4.91	1.08	2.73	7.28
Total	6.93	14.54	15.09	14.10	13.15	11.57	14.12	11.65	15.16	12.80	7.19	7.82	11.42	15.03
September	3.87	2.52	4.89	1.53	2.44	4.72	5.17	3.14	1.08	1.76	2.14	2.78	5.65	1.56
October	1.85	8.93	2.35	4.31	1.76	1.30	2.32	3.23	3.62	2.57	2.55	4.33	1.87	3.69
November	3.00	3.27	2.56	1.92	3.02	2.19	3.43	2.29	3.16	5.12	2.88	2.72	3.22	1.31
Total	8.72	14.72	9.80	7.76	7.22	8.21	10.92	8.66	7.86	9.45	7.57	9.83	10.74	6.56
Yearly total	33.59	40.50	39.42	42.23	34.78	32.19	32.22	36.72	37.99	40.90	28.13	37.85	32.75	40.57

Month.	1868.	1869.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.
December	1.03	1.85	2.88	1.65	1.65	2.18	3.03	0.76	1.11	2.42	0.71	6.16	4.23	2.01
January	3.15	3.28	5.38	2.30	0.78	3.32	3.61	2.14	1.67	1.95	4.45	3.54	2.96	2.86
February	1.68	3.23	5.19	2.00	1.74	2.11	2.90	1.65	4.09	0.36	4.12	2.80	2.67	2.50
March	1.82	2.49	3.84	7.29	2.70	3.65	1.97	3.27	4.28	3.33	2.18	3.79	2.17	2.80
April	4.01	2.19	2.70	3.79	1.81	1.99	4.97	3.63	3.51	1.42	3.99	3.17	2.75	1.34
May	7.03	4.57	1.78	4.97	4.79	1.98	2.32	2.57	2.96	2.77	3.65	0.89	3.35	3.90
Total	18.72	17.61	21.77	22.00	13.47	15.23	18.80	14.02	17.52	12.25	19.10	19.35	18.13	16.41
June	3.64	1.39	7.48	7.25	4.68	0.99	4.71	3.98	4.40	4.60	4.54	5.62	2.21	3.76
July	1.61	2.89	7.19	9.37	5.60	5.97	6.78	2.46	4.97	4.00	5.52	5.10	3.78	2.22
August	3.62	2.89	8.47	10.59	4.84	2.27	1.94	6.55	0.53	4.57	3.76	4.25	2.84	2.07
Total	8.87	7.17	23.14	27.21	15.12	9.23	13.43	12.99	9.90	13.17	13.82	13.97	18.83	8.05
September	7.11	3.35	5.02	0.85	2.55	4.78	4.01	2.63	5.17	1.82	3.20	3.47	2.86	2.38
October	1.91	13.48	4.05	3.34	4.68	5.57	1.77	5.97	1.64	7.86	3.37	1.24	2.45	3.19
November	5.45	1.56	3.06	3.38	2.77	3.75	2.19	2.29	2.65	2.70	4.43	2.56	2.49	3.44
Total	14.47	18.39	12.13	7.57	10.00	14.10	7.97	10.89	9.46	12.38	11.00	7.27	7.80	9.01
Yearly total	42.06	43.17	57.04	57.78	38.59	38.56	40.20	37.90	36.88	37.80	43.92	40.59	34.76	33.47

Month.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.
December	4.88	2.24	2.55	3.20	1.50	2.19	5.43	3.90	2.14	2.94	3.23	0.82	2.54
January	2.64	2.43	2.98	3.09	3.66	3.02	3.04	2.82	2.28	6.12	4.08	1.31	2.54
February	3.31	3.00	3.86	1.38	1.40	2.86	2.07	1.81	2.52	4.14	2.13	4.63	2.61
March	1.79	1.77	4.00	0.62	2.73	2.90	5.26	1.76	3.72	3.12	1.64	2.00	0.85
April	1.27	2.65	2.09	2.89	3.67	2.49	1.95	1.25	1.64	2.27	0.56	2.10	2.02
May	4.15	3.20	2.79	1.92	3.40	2.27	2.98	3.32	5.19	1.69	5.30	5.08	4.64
Total	18.04	15.29	18.27	13.10	16.36	15.73	20.73	14.26	17.49	20.28	16.94	15.94	15.20
June	3.98	6.30	1.80	1.98	3.19	2.99	3.18	6.43	2.72	2.65	4.41	2.92	3.21
July	3.97	5.96	5.04	1.98	2.56	4.61	2.52	4.19	2.37	6.11	4.22	1.82	2.98
August	1.38	3.69	5.27	7.58	0.87	4.61	4.74	3.63	5.66	5.88	6.70	7.21	2.24
Total	9.33	15.95	12.11	11.54	6.62	12.21	10.44	14.25	10.75	14.54	15.33	11.95	8.49
September	7.79	3.19	1.80	2.00	2.51	1.94	4.68	3.68	8.91	1.94	2.08	3.20	4.18
October	0.27	3.49	2.64	5.54	2.43	2.22	6.10	3.48	5.76	2.13	0.60	1.67	4.62
November	0.97	1.14	3.44	3.90	5.40	4.36	4.48	5.00	1.18	2.40	2.29	0.91	1.96
Total	9.03	7.82	7.88	11.44	10.34	8.52	15.26	12.16	15.85	6.47	4.97	5.78	10.76
Yearly total	36.40	39.06	38.25	36.08	33.32	36.46	46.43	40.67	44.09	41.29	37.24	33.67	34.45

TABLE NO. 23.—*Record of precipitation at Alfred for the water years 1889 to 1898, inclusive.*

Month.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	......	2.55	2.72	3.60	0.62	3.13	3.02	4.03	1.64	*a* 2.90	......
January	......	3.30	2.22	4.06	4.45	3.02	3.39	2.51	3.33	*a* 3.53	......
February	......	2.31	4.27	2.76	4.15	2.81	0.95	3.28	1.67	1.46	......
March	......	3.01	2.54	3.18	3.34	1.35	1.30	4.33	3.24	3.82	......
April	......	3.56	2.21	0.55	2.23	8.09	1.61	1.69	2.69	2.50	......
May	2.80	6.95	0.60	5.80	5.89	7.91	2.90	2.62	3.35	3.27	......
Total	......	21.68	14.56	19.95	20.68	26.31	13.17	18.46	15.92	17.48	......
June	5.66	3.42	2.46	5.48	1.93	2.14	4.69	4.07	2.97	3.79	......
July	4.47	1.63	5.30	2.14	3.02	2.96	2.60	4.49	5.47	2.55	......
August	1.85	6.17	5.01	3.72	4.95	0.56	4.27	1.11	1.78	6.21	......
Total	11.98	11.22	12.77	11.34	9.90	5.66	11.56	9.67	10.22	12.55	......
September	1.82	9.47	1.22	2.04	4.90	6.88	0.95	5.04	2.88	1.13	......
October	2.44	4.79	2.61	1.44	3.30	3.64	1.13	5.02	1.02	5.12	......
November	3.48	1.60	1.73	4.31	2.98	1.37	3.34	2.15	*a* 3.32	2.99	......
Total	7.74	15.86	5.56	7.79	11.18	11.89	5.42	12.21	7.22	9.24	......
Yearly total	......	48.76	32.89	39.08	41.76	43.86	30.15	40.34	33.36	30.27	38.83

a Mean of—			
Angelica	3.07	3.10	3.16
S. Canisteo	3.56	2.71	3.90
	2)6.63	5.81	7.06
	3.32	2.90	3.53

TABLE NO. 24.—*Record of precipitation at Angelica for the water years 1889 to 1898, inclusive.*

Month.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	*a* 2.84	3.29	2.77	3.84	1.13	3.53	2.23	4.02	1.64	3.10	......
January	3.10	3.47	1.86	3.27	2.44	4.45	3.35	2.34	3.12	3.16	......
February	1.26	2.33	1.63	3.06	4.37	2.81	1.38	4.16	1.57	1.41	......
March	1.67	2.63	*b* 2.54	3.55	2.87	1.78	2.86	4.21	4.21	3.39	......
April	3.81	3.59	2.46	1.57	4.37	7.77	2.72	1.58	3.15	2.72	......
May	5.12	7.38	1.25	7.31	5.65	8.82	2.01	1.99	4.07	3.51	......
Total	17.80	22.69	12.51	22.60	20.83	29.16	14.55	18.30	17.76	17.29	......
June	7.43	4.52	3.48	5.14	2.35	2.02	4.10	3.26	5.56	5.28	......
July	5.00	2.94	*b* 5.30	2.55	1.79	4.14	2.40	5.66	5.14	1.79	......
August	2.60	6.72	5.39	3.67	5.22	2.26	3.96	2.63	1.77	8.87	......
Total	15.03	14.18	14.17	11.36	9.36	8.42	10.46	11.55	12.47	15.94	......
September	2.34	8.72	1.37	2.68	2.67	7.14	1.92	4.96	1.74	1.93	......
October	3.33	4.72	2.61	2.51	2.49	3.37	1.32	3.18	0.65	4.76	......
November	4.27	2.28	2.33	3.60	2.12	1.70	3.46	2.08	3.07	3.00	......
Total	9.94	15.72	6.31	8.79	7.28	12.21	6.70	10.22	5.46	9.69	......
Yearly total	42.77	52.59	32.99	42.75	37.47	49.79	31.71	40.07	35.69	42.92	40.88

a Mean of all Decembers.

b Alfred record.

TABLE NO. 25.—*Record of precipitation at Arcode for the water years 1891 to 1898, inclusive.*

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	1.64	4.09	1.51	3.82	2.06	3.92	1.66	3.47	....
January	1.82	2.52	1.69	3.12	3.79	2.35	2.70	4.29	....
February	4.04	2.35	4.60	2.50	0.99	3.86	1.76	1.66	....
March	1.87	1.77	2.64	1.83	1.09	3.50	2.90	2.97	....
April	1.32	1.34	4.47	6.02	1.51	1.36	3.06	2.90	....
May	1.87	7.16	7.28	10.05	1.90	2.48	4.30	4.62	....
Total	12.56	19.23	22.19	27.34	11.34	17.47	16.28	19.91	....
June	4.69	9.33	3.63	5.35	4.04	3.19	2.64	5.68	....
July	5.11	4.59	2.88	2.70	2.38	6.39	8.35	2.98	....
August	5.00	4.78	6.55	1.57	5.71	3.77	3.62	6.20	....
Total	14.80	18.70	13.06	9.62	12.13	13.35	14.61	14.86	....
September	2.36	2.59	3.19	5.54	1.61	6.18	1.13	4.77	....
October	2.16	3.63	3.77	4.62	2.26	3.22	0.97	5.31	....
November	3.10	3.33	1.95	1.82	2.77	3.68	4.35	3.79	....
Total	7.62	9.55	8.91	11.98	6.64	13.08	6.45	13.87	....
Yearly total	34.98	47.48	44.16	48.94	30.11	43.90	37.34	48.64	41.94

TABLE NO. 26.—*Record of precipitation at Auburn for certain water years, as indicated, from 1827 to 1898, inclusive.*

Month.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.
December	1.96	4.09	1.05	0.66	4.40	*b* 1.62	1.95	2.25	1.88	1.63	0.57
January	2.75	1.65	2.85	1.04	....	1.88	1.48	0.78	1.77	6.70	1.05
February	1.51	1.40	1.77	0.48	....	2.50	1.60	1.38	1.47	3.20	1.20
March	0.93	1.84	1.01	4.02	....	1.19	1.45	1.00	1.77	1.28	2.50
April	2.27	2.93	1.48	1.75	....	1.46	1.65	1.30	4.68	2.80	0.50
May	2.03	3.21	1.94	4.20	....	2.37	7.82	2.82	1.13	3.80	4.55
Total	11.45	15.12	10.10	12.15	....	11.02	15.95	9.53	12.70	19.41	10.37
June	4.88	3.31	3.95	7.83	....	1.43	1.43	3.42	6.30	3.02	3.00
July	2.76	7.45	4.07	2.91	....	3.35	5.63	2.25	3.12	1.05	3.80
August	3.15	4.65	3.45	1.35	....	6.75	3.62	2.35	4.30	2.32	4.55
Total	10.79	15.41	11.47	12.09	....	11.53	10.68	8.02	13.81	6.39	11.35
September	2.09	3.46	4.36	3.25	....	3.22	2.80	4.14	2.02	3.20	1.68
October	5.78	2.70	2.70	2.95	....	2.05	3.43	2.20	3.65	2.49	3.30
November	1.55	1.26	2.30	3.70	....	2.66	0.79	1.18	2.40	0.87	1.80
Total	9.42	7.42	9.36	9.90	....	7.93	7.02	7.52	8.07	6.56	6.78
Yearly total	31.66	37.95	30.93	34.14	....	30.48	33.65	25.07	34.58	32.36	28.50

a Onondaga Hollow record.

b Mean of—

Ledyard	1.42
Canandaigua	1.81
	2)3.23
	1.62

Table No. 26.—*Record of precipitation at Auburn for certain water years, as indicated, from 1827 to 1898, inclusive*—Continued.

Month.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.
December	1.10	1.15	3.15	3.10	2.25	2.82	4.22	4.55	1.48	3.25	6.21
January	1.13	2.70	3.10	3.48	1.25	2.74	2.70	4.72	2.46	2.49	1.91
February	1.78	0.75	2.55	3.59	4.10	2.12	2.26	2.74	2.90	2.24	0.83
March	1.30	1.60	1.20	1.56	3.28	3.89	5.40	1.47	2.28	1.72	2.44
April	0.99	2.20	2.65	3.26	3.32	3.61	4.68	2.61	0.92	2.68	1.07
May	1.20	5.10	4.70	3.25	2.67	5.12	3.51	2.67	1.67	1.75	6.12
Total	7.50	13.50	17.35	18.24	16.87	20.30	22.77	18.76	11.71	14.13	18.58
June	3.00	7.46	3.39	1.30	3.17	3.49	3.03	1.76	2.73	2.16	4.03
July	2.50	1.00	3.23	2.09	4.43	2.09	2.27	2.89	2.27	3.86	4.99
August	2.64	3.70	2.89	1.15	3.89	3.78	3.01	2.05	2.58	3.70	3.88
Total	8.14	12.16	9.51	4.54	11.49	9.36	8.31	6.70	7.58	9.72	12.90
September	1.70	1.80	2.57	1.86	4.34	6.14	1.51	4.10	4.37	3.50	2.77
October	2.35	1.00	4.55	0.90	3.97	6.40	3.07	3.66	4.40	5.55	2.99
November	2.00	2.96	3.45	3.49	3.59	6.22	3.79	4.27	3.30	3.90	3.00
Total	6.05	5.76	10.57	6.25	11.90	18.76	8.37	12.03	12.07	12.95	8.76
Yearly total	21.69	31.42	37.43	29.03	40.28	48.42	39.45	37.49	31.36	36.80	40.24

Month.	1849.	a1884.	1885.	1886.	1887.	1888.	1889.	1890.	1897.	1898.	Mean.
December	4.74	0.73	1.64	2.78	2.95	3.40	3.94	3.07	......	2.92	......
January	4.38	2.96	2.78	3.82	3.05	2.37	4.31	......	......	3.89	......
February	2.52	1.88	3.56	3.03	4.49	1.63	......	......	......	2.71	......
March	3.78	0.86	1.33	3.78	3.64	3.13	......	......	......	2.31	......
April	0.70	0.30	2.61	3.69	1.66	4.11	......	......	......	2.94	......
May	4.30	3.67	2.46	2.92	1.56	4.29	3.60	......	......	5.24	......
Total	20.42	10.40	14.38	20.02	17.35	18.93	......	......	......	20.01	......
June	4.30	1.68	3.10	3.53	3.05	7.02	7.49	......	......	3.72	......
July	0.95	2.78	4.64	7.83	6.97	2.74	7.96	......	......	1.32	......
August	1.29	2.77	6.33	2.49	3.73	3.73	2.96	......	......	6.61	......
Total	6.54	7.23	14.07	13.85	13.75	13.49	18.41	......	......	11.65	......
September	5.56	3.55	3.28	4.29	0.93	2.27	4.10	......	3.29	5.30	......
October	4.79	3.38	3.95	2.85	1.75	4.56	3.38	......	0.75	4.52	......
November	4.73	2.05	2.38	6.89	2.13	4.60	6.07	......	4.49	3.65	......
Total	15.08	8.98	9.61	14.03	4.81	11.43	13.55	......	8.53	13.47	......
Yearly total	42.04	26.61	38.06	47.90	35.91	43.85	......	......	......	45.13	35.44

a Geneva record.

TABLE No. 27.—*Record of precipitation at Avon for certain water years, as indicated, from 1891 to 1898, inclusive.*

Month.	1891.	1892.	1893.	1895.	1896.	1897.	1898.	Mean.
December	1.05	3.96	0.86	....	2.58	0.79	1.65	....
January	1.99	2.14	0.55	....	1.97	1.97	1.98	....
February	2.88	2.45	2.86	....	*a* 5.35	0.64	1.51	....
March	3.63	0.63	2.62	....	3.23	1.87	1.93	....
April	1.13	0.70	2.18	....	1.05	1.21	1.46	....
May	1.63	4.08	4.00	....	1.98	1.75	2.27	....
Total	12.31	13.98	13.07	....	16.16	8.23	10.80	....
June	3.67	7.77	1.02	....	1.97	1.96	3.73	....
July	3.94	2.53	....	....	4.87	4.08	2.09	....
August	3.03	4.61	....	....	3.92	0.90	*a* 4.56	....
Total	10.64	14.91	....	....	10.76	6.94	10.38	....
September	1.42	1.16	....	1.81	3.82	1.42	3.12	....
October	2.46	1.42	....	0.46	1.48	0.72	2.72	....
November	1.50	3.27	....	3.51	1.82	2.19	4.76	....
Total	5.38	5.85	....	....	7.12	4.33	10.60	....
Yearly total	28.33	34.72	....	....	34.04	19.50	31.78	29.67

a Mount Morris record.

TABLE No. 28.—*Record of precipitation at Baldwinville for the water years 1890 to 1898, inclusive.*

Month.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	....	3.01	4.10	5.01	4.40	2.62	5.39	1.72	3.64	....
January	....	3.07	4.36	2.22	3.07	3.26	3.53	5.40	4.50	....
February	....	3.95	2.39	5.78	3.77	4.12	6.39	0.99	1.51	....
March	....	5.91	4.52	2.56	2.18	1.07	4.52	5.13	1.52	....
April	....	1.62	1.65	4.38	2.20	1.80	0.76	2.18	2.23	....
May	5.75	0.86	5.69	5.12	5.96	2.39	2.70	2.22	3.84	....
Total	....	18.42	22.71	25.07	21.58	15.26	23.29	17.64	17.24	....
June	5.64	0.66	4.81	2.87	5.52	2.09	1.49	3.23	*a*2.51	....
July	1.90	3.68	4.64	7.05	2.97	3.22	4.34	5.95	1.59	....
August	3.89	2.10	5.07	5.15	1.64	2.48	3.06	2.63	5.98	....
Total	11.43	6.44	14.52	15.07	10.13	7.79	8.89	11.81	10.08	....
September	8.72	1.04	1.18	2.63	4.88	2.63	5.63	1.20	3.35	....
October	6.30	2.77	3.46	1.95	4.17	1.35	2.07	0.65	4.85	....
November	4.34	2.50	4.28	2.11	3.12	3.13	3.07	5.05	4.31	....
Total	19.36	6.31	8.92	6.69	12.17	7.11	10.77	6.90	11.51	....
Yearly total	....	31.17	46.15	46.83	43.88	30.16	42.95	36.35	38.83	39.54

a Phoenix record.

TABLE NO. 29.—*Record of precipitation at Belleville for certain water years, as indicated, from 1830 to 1845, inclusive.*

Month.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1842.	1843.	1844.	1845.	Mean
December	*a*2.54	1.18	1.20	*b*2.16	3.10	1.04	2.32	2.80	*c*2.97	3.31	2.43	1.70	......
January	0.56	0.19	......	2.35	1.70	1.60	3.99	......	1.90	3.05	2.54	......	......
February	0.18	1.37	......	3.60	1.30	3.13	0.80	......	3.12	2.74	0.22	......	......
March	1.35	0.37	......	1.80	1.50	0.70	1.15	......	2.57	2.97	0.95	......	......
April	0.74	2.45	......	0.75	3.30	0.84	2.42	......	3.29	1.51	1.45	......	......
May	1.34	1.22	......	4.40	0.69	1.34	5.42	......	2.29	1.60	3.75	......	......
Total	6.71	6.78	......	15.06	11.59	8.65	16.10	......	16.14	15.18	11.34	......	......
June	4.77	2.10	......	0.61	2.56	0.89	3.66	......	3.29	3.65	0.75	......	......
July	3.36	6.48	......	1.15	1.43	1.96	1.40	......	3.04	3.24	4.60	......	......
August	0.88	2.53	......	2.12	0.75	6.53	1.35	......	2.63	2.95	3.66	......	......
Total	9.01	11.11	......	3.88	4.74	9.38	6.41	......	8.96	9.84	9.01	......	......
September	4.68	5.73	......	1.42	1.38	2.29	2.25	......	5.81	2.46	0.19	......	......
October	2.45	5.91	......	2.21	1.30	6.38	3.15	......	6.62	4.57	3.43	......	......
November	4.60	3.30	......	2.31	2.04	2.53	1.20	......	4.78	3.84	1.14	......	......
Total	11.73	14.94	......	5.94	4.72	11.20	6.60	......	17.21	10.87	4.76	......	......
Yearly total	27.45	32.83	......	24.88	21.05	29.23	29.11	......	42.31	35.89	25.11	......	29.76

a Mean of—

Lowville	2.35
Potsdam	2.73
	2)5.08
	2.54

b Lowville record.

c Mean of—

Sacketts Harbor	3.11
Lowville	2.37
Mexico	3.42
	3)8.90
	2.97

TABLE NO. 30.—*Record of precipitation at Binghamton for the water years 1890 to 1898, inclusive.*

Month.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	....	3.15	3.24	1.27	2.91	3.31	3.63	1.20	4.03	....
January	....	3.30	4.21	2.42	2.18	3.23	*a* 1.30	1.45	3.93	....
February	....	3.27	1.90	4.16	2.98	1.60	4.28	2.09	2.71	....
March	....	4.46	3.93	2.80	1.51	1.58	4.68	2.92	2.99	....
April	....	2.16	1.13	3.36	3.53	2.29	0.63	2.33	3.37	....
May	....	1.16	6.08	5.16	5.34	2.92	3.11	4.88	4.02	....
Total	....	17.50	20.49	19.17	18.45	14.93	17.63	14.87	21.05	....
June	4.77	3.55	5.43	2.58	1.97	2.05	2.64	3.76	2.16	....
July	2.24	3.30	2.92	4.10	2.88	4.06	3.85	2.54	2.05	....
August	6.29	6.59	6.04	4.88	1.47	3.39	1.42	1.84	6.48	....
Total	13.30	13.44	14.39	11.56	6.32	9.50	7.91	8.14	10.69	....
September	4.04	1.54	1.33	4.50	4.98	2.11	4.62	3.57	2.70	....
October	4.72	4.24	1.54	1.68	5.62	0.82	3.68	0.82	5.79	....
November	1.50	2.65	2.65	1.38	1.98	2.94	2.66	2.89	3.15	....
Total	10.26	8.43	5.52	7.56	12.58	5.87	10.96	7.28	11.64	....
Yearly total	....	39.37	40.40	38.29	37.35	30.30	36.50	30.29	43.38	36.98

a Mean of—

Deposit	1.30
Waverly	1.30
	2)2.60
	1.30

TABLE NO. 31.—*Record of precipitation at Bolivar for certain water years, as indicated, from 1891 to 1898, inclusive.*

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	*a* 2.32	3.44	1.21	4.08	*b* 2.15	4.03	1.38	3.02	....
January	*a* 2.02	2.87	*b* 1.16	3.68	3.35	1.95	2.31	3.91	....
February	*a* 4.42	3.16	*b* 4.96	2.02	0.95	2.93	1.44	1.76	....
March	2.27	2.84	*b* 2.33	1.78	1.55	3.79	3.37	5.36	....
April	*a* 2.19	0.98	4.40	....	2.52	1.48	2.48	2.90	....
May	*a* 1.02	11.02	*b* 5.70	....	2.58	4.70	2.80	3.46	....
Total	14.24	24.31	19.85	....	13.10	18.88	13.78	20.41	....
June	2.44	10.01	*b* 2.04	....	4.67	4.29	3.44	5.12	....
July	6.22	4.14	*b* 2.01	....	1.78	7.75	6.30	*a* 2.57	....
August	5.02	2.42	4.12	....	3.76	1.25	3.26	6.28	....
Total	13.68	16.57	8.17	....	10.21	13.29	13.06	13.97	....
September	1.89	2.35	3.65	....	1.93	4.86	2.06	1.27	....
October	2.65	2.21	2.58	3.72	1.67	4.03	0.70	4.97	....
November	2.69	3.17	1.83	....	4.02	*b* 2.29	4.69	3.40	....
Total	7.23	7.73	8.06	....	7.62	11.18	7.45	9.64	....
Yearly total	35.15	48.61	36.06	....	30.93	43.35	34.29	44.02	38.92

a Mean of—

Humphrey	1.91	1.82	4.55	2.17	1.45	2.59
Alfred	2.72	2.22	4.27	2.21	0.60	2.55
2)	4.63	4.04	8.82	4.38	2.05	5.14
	2.32	2.02	4.42	2.19	1.02	2.57

b Friendship record.

TABLE NO. 32.—*Record of precipitation at Bridgewater for certain water years, as indicated from 1833 to 1838, inclusive.*

Month.	1833.	1834.	1835.	1836.	1837.	1838.	Mean.
December	*a* 3.81	5.15	8.65	1.66	*a* 2.44	1.95	....
January	2.75	4.19	4.10	....	5.99	....	....
February	2.24	1.26	5.01	....	2.87	....	....
March	3.37	1.98	4.96	....	1.72	....	....
April	0.72	2.63	11.31	....	2.40	....	....
May	6.34	2.16	2.49	....	2.28	....	....
Total	19.23	17.37	36.52	....	17.70	....	....
June	3.42	3.50	8.69	....	5.85	....	....
July	7.16	3.27	4.70	....	4.14	....	....
August	2.48	2.26	4.38	....	1.86	....	....
Total	13.06	9.03	17.77	....	11.85	....	....
September	3.09	4.42	1.31	....	1.40	....	....
October	4.70	3.01	5.15	....	4.61	....	....
November	1.45	2.79	2.20	....	2.05	....	....
Total	9.24	10.22	8.66	....	8.06	....	....
Yearly total	41.53	36.62	62.95	....	37.61	....	44.68

a Mean of—

Hamilton	3.47	2.37
Utica	5.15	2.51
2)	7.62	4.88
	3.81	2.44

TABLE NO. 33.—*Record of precipitation at Brookfield for certain water years, as indicated from 1890 to 1898, inclusive.*

Month.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	*c*1897.	*c*1898.	Mean.
December	*a*3.00	5.60	5.60	1.27	5.29	1.90	4.73	*b*1.33	3.43	....
January	4.95	6.22	3.94	1.92	3.69	1.70	1.50	....	5.30	....
February	3.56	5.06	0.74	3.29	4.05	2.25	5.69	....	3.60	....
March	4.11	3.58	3.97	2.08	2.65	1.37	4.23	....	2.39	....
April	3.26	1.76	0.67	1.71	2.18	2.14	1.20	....	4.39	....
May	7.84	1.96	7.99	5.87	6.50	2.76	1.54	....	4.43	....
Total	26.72	24.18	22.91	16.14	24.36	12.12	18.89	....	23.54	....
June	4.72	2.34	6.34	0.77	2.20	1.90	2.75	....	2.57	....
July	1.97	3.78	7.34	4.33	0.94	1.33	3.29	....	2.63	....
August	6.94	5.59	8.31	6.65	1.02	3.43	2.82	1.93	6.39	....
Total	13.63	11.71	21.99	11.75	4.16	6.66	8.86	....	11.59	....
September	6.36	1.86	2.09	2.62	3.56	1.92	1.97	3.01	3.74	....
October	6.01	3.70	2.88	0.75	3.08	0.66	1.37	0.68	6.49	....
November	3.31	2.92	3.61	1.11	1.95	3.11	*b*2.81	4.34	3.32	....
Total	15.68	8.48	8.58	4.48	8.50	5.69	6.15	8.03	13.55	....
Yearly total	56.03	44.37	53.48	32.37	37.11	24.47	33.90	....	48.68	41.30

a Mean of—

Cooperstown	2.68
Utica	3.31
2)	5.99
	3.00

b Mean of—

New Lisbon	2.96	0.95
Oxford	2.66	1.72
2)	5.62	2.67
	2.81	1.33

c Bouckville Record.

TABLE NO. 34.—*Record of precipitation at Burlington, Vt., for the water years 1884 to 1898, inclusive.*

Month.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.
December	....	2.60	2.07	1.70	3.44	1.63	1.48	1.90
January	....	2.36	1,68	1.87	1.06	3.57	2.05	2.85
February	....	1.40	1.06	1.67	0.79	1.59	1.98	1.01
March	....	0.86	1.33	1.87	3.71	2.35	*b*2.68	1.70
April	....	2.53	1.68	2.21	1.93	1.51	*b*1.46	2.77
May	....	2.48	2.61	2.00	3.26	4.28	6.12	2.16
Total	....	12.23	10.43	11.32	14.19	14.93	15.77	12.39
June	....	*a*1.23	1.98	4.38	3.95	6.26	*b*3.35	1.48
July	....	3.80	3.94	2.23	1.47	4.09	3.33	3.48
August	....	3.41	3.22	2.80	4.10	2.48	6.76	3.25
Total	....	8.44	9.14	9.41	9.52	12.83	13.44	8.21
September	....	3.50	3.73	2.01	5.68	4.82	3.84	2.44
October	....	4.77	1.25	1.99	3.94	3.32	2.02	3.02
November	2.95	3.94	4.29	4.67	3.60	2.46	2.31	2.73
Total	....	12.21	9.27	8.67	13.22	10.60	8.17	8.19
Yearly total	....	32.88	28.84	29.40	36.93	38.36	37.38	28.79

TABLE NO. 34.—*Record of precipitation at Burlington, Vt., for the water years 1884 to 1898, inclusive*—Continued.

Month.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	2.23	1.00	2.35	2.02	1.74	0.83	2.10	....
January	2.76	0.70	1.30	1.31	0.63	2.50	2.60	....
February	1.67	1.24	0.99	1.16	1.94	1.08	2.98	....
March	0.92	0.52	1.31	0.77	3.54	2.49	1.04	....
April	1.02	1.70	0.86	1.65	0.60	4.01	2.33	....
May	4.28	3.17	3.54	8.79	1.25	5.00	2.14	....
Total	12.88	8.33	10.35	10.70	9.70	15.91	13.19	....
June	6.72	1.73	1.45	2.78	3.13	5.63	2.93	....
July	7.66	3.74	1.57	2.46	3.83	8.48	1.51	....
August	*b*7.18	8.31	1.49	4.84	4.09	4.08	4.58	....
Total	21.56	13.78	4.51	10.08	11.05	18.19	9.02	....
September	3.22	*b*2.12	*b*2.79	3.64	3.59	2.13	5.01	....
October	*b*1.12	1.72	3.59	0.23	2.53	1.53	4.01	....
November	3.28	1.41	1.96	4.32	2.43	4.41	1.90	....
Total	7.62	5.25	8.34	8.19	8.55	8.07	10.92	....
Yearly total	42.06	27.36	23.20	28.97	29.30	42.17	33.13	32.77

a Keene Valley record.

b Plattsburg, N. Y., record.

TABLE NO. 35.—*Record of precipitation at Cambridge for the water years 1827 to 1839, inclusive.*

Month.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	Mean
December	*a*2.36	4.25	0.43	3.12	5.60	2.50	2.51	1.17	1.98	0.92	1.52	2.18	2.10	2.36
January	6.43	2.49	4.10	1.90	1.90	4.17	1.94	1.41	4.25	6.88	2.70	3.05	2.47	3.36
February	2.97	2.00	2.25	2.00	2.65	4.16	1.93	1.70	2.15	4.15	3.63	2.55	1.88	2.61
March	2.61	1.30	2.40	2.29	3.60	3.67	2.09	2.43	2.20	0.96	2.30	0.75	0.95	2.12
April	7.24	1.77	4.85	1.24	3.20	4.00	1.35	2.58	1.95	2.08	2.90	0.98	9.49	3.36
May	3.68	4.25	3.77	1.86	2.30	3.30	9.67	2.56	2.65	2.65	4.50	4.04	2.17	3.65
Total	25.29	16.06	17.80	12.41	19.25	21.80	19.49	11.85	15.18	17.64	17.55	13.55	19.06	17.46
June	4.49	5.36	4.97	5.15	3.80	1.70	3.79	2.74	6.25	3.77	2.80	8.78	7.02	4.66
July	5.01	4.91	2.50	3.66	5.79	4.35	4.36	2.68	4.48	2.36	2.80	2.46	5.48	3.91
August	4.02	5.54	0.81	1.20	4.72	6.83	6.74	1.37	5.30	1.66	2.53	8,62	2.31	3.98
Total	13.52	15.81	8.28	10.01	14.31	12.88	14.89	6.79	16.03	7.79	8.13	19.86	14.81	12.55
September	3.66	6.33	3.30	3.50	4.22	3.22	2.79	3.47	1.10	2.44	1.15	4.10	3.17	3.27
October	4.72	2.47	3.03	3.35	4.22	4.22	8.35	4.21	2.67	3.10	2.28	3.15	1.10	3.60
November	2.93	6.83	3.94	3.35	3.95	4.22	3.13	2.05	2.00	2.48	1.80	3.58	2.48	3.29
Total	11.31	15.63	10.27	10.20	12.39	11.76	14.27	9.73	5.77	8.02	5.23	10.83	6.75	10.16
Yearly total	50.12	47.50	36.35	32.62	45.95	46.44	48.65	28.37	36.98	33.45	30.91	44.24	40.62	40.17

a Mean of twelve years.

TABLE NO. 36.—*Record of precipitation at Canandaigua for the water years 1829 to 1838, inclusive.*

Month.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	Mean.
December	*a* 1.05	2.17	2.75	1.81	2.63	3.86	2.21	2.05	1.59	2.85	......
January	3.15	3.84	3.32	2.32	1.71	2.34	2.64	6.00	2.62	1.95	......
February	2.86	1.60	2.49	3.86	3.20	3.66	3.95	3.49	4.25	1.90	......
March	2.87	2.70	2.03	1.11	0.85	3.41	3.12	2.37	2.62	2.01	......
April	3.27	1.48	3.76	2.21	1.46	3.13	3.76	3.80	1.10	2.80	......
May	2.60	4.67	3.20	3.64	6.87	3.60	4.30	7.95	3.35	5.10	......
Total	15.80	15.96	17.55	14.95	16.72	20.00	19.98	25.66	15.53	16.61	......
June	1.47	7.78	4.49	1.15	2.85	1.80	3.80	5.10	3.72	6.75	......
July	3.03	3.58	3.91	3.30	4.91	3.36	4.05	0.75	3.18	2.10	......
August	1.34	1.42	3.78	3.03	4.35	4.75	4.42	1.60	4.73	1.96	......
Total	5.84	12.78	12.18	7.48	12.11	9.91	12.27	7.45	11.63	10.81	......
September	3.54	1.70	3.01	2.00	3.54	2.90	3.70	2.00	4.00	1.67	......
October	2.15	2.08	3.90	2.11	3.85	2.31	4.00	3.60	3.99	4.66	......
November	1.75	3.50	3.11	2.59	2.40	3.11	3.06	1.25	3.81	3.17	......
Total	7.44	7.28	10.02	6.70	9.79	8.32	10.76	6.85	11.80	9.50	......
Yearly total	29.08	36.02	39.75	29.13	38.62	38.23	43.01	39.96	38.96	36.92	36.97

a Auburn record.

TABLE NO. 37.—*Record of precipitation at Canton for certain water years as indicated from 1889 to 1898, inclusive.*

Month.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	*a*2.68	3.63	1.94	3.31	1.09	......	2.35	6.31	0.80	3.21	......
January	6.13	4.46	2.57	2.87	1.68	......	2.30	2.25	*b*2.58	6.76	......
February	2.52	4.19	1.86	1.34	1.94	......	2.55	5.45	1.65	3.13	......
March	0.91	1.68	2.61	2.52	0.92	......	2.00	4.49	*b*2.95	1.47	......
April	2.61	2.14	2.43	1.37	2.29	1.59	2.47	2.66	3.16	1.47	......
May	3.25	4.76	1.44	5.21	7.21	4.11	1.67	1.51	3.49	2.69	......
Total	18.10	20.86	12.85	16.62	15.13	......	13.34	22.67	14.63	18.73	......
June	6.70	3.33	1.46	6.81	3.05	2.20	2.34	3.39	2.50	3.93	......
July	8.25	3.80	6.25	3.98	......	2.92	2.96	3.25	7.58	1.96	......
August	2.08	4.19	6.06	8.93	......	0.85	5.14	3.89	3.33	6.00	......
Total	17.03	11.32	13.77	19.72	......	5.97	10.44	10.53	13.41	11.89	......
September	2.67	4.94	1.33	2.68	......	3.36	5.03	5.46	1.24	6.63	......
October	3.52	2.28	3.12	1.61	......	4.23	0.53	1.02	0.64	4.35	......
November	3.59	4.06	3.06	4.19	......	2.75	5.42	3.26	5.38	2.01	......
Total	9.78	11.28	7.51	8.48	......	10.34	10.98	9.74	7.26	12.99	......
Yearly total	44.91	43.46	34.13	44.82	......	......	34.76	42.94	35.30	43.61	40.49

a Mean of—

Utica	3.12
Palermo	2.25
2)	5.37
	2.68

b Mean of—

De Kalb Junction	2.47	3.19
Potsdam	2.70	2.70
2)	5.17	5.89
	2.58	2.95

TABLE NO. 38.—*Record of precipitation at Cazenovia for certain water years as indicated from 1830 to 1849, inclusive.*

Month.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.
December	a 1.14	3.27	0.25	3.50	2.95	2.30	3.83	a 0.87	2.47	1,14
January	2.49	3.40	1.94	1.42	1.56	1.44	....	2.73	2.00	4.58
February	0.91	2.01	3.10	1.11	1.38	1.61	....	2.25	1.33	1.21
March	3.92	1.88	1.31	1.85	2.51	0.86	....	2.85	1.29	2.52
April	2.10	4.81	2.42	1.98	2.48	4.60	....	1.64	1.78	1.73
May	3.51	2.21	3.06	5.20	3.42	2.77	....	3.53	6.42	4.67
Total	14.07	17.58	12.08	15.06	14.30	13.58	....	13.87	15.29	15.85
June	7.03	5.10	2.20	2.78	5.10	5.97	....	5.53	7.65	4.80
July	5.00	4.54	4.35	6.31	1.80	3.03	....	4.88	3.48	3.28
August	2.14	3.73	6.64	2.79	2.32	4.24	....	4.27	5.91	2.66
Total	14.26	13.37	13.19	11.88	9.22	13.24	....	14.68	17.04	10.74
September	4.00	2.94	2.65	4.22	4.45	1.97	....	2.63	2.31	2.93
October	2.27	3.66	2.70	4.80	3.94	2.53	....	5.29	4.44	1.36
November	4.86	2.76	3.92	2.16	2.38	1.50	....	2.58	3.55	4.00
Total	11.13	9.36	9.27	11.18	10.77	6.00	....	10.50	10.30	8.29
Yearly total	39.46	40.31	34.54	38.12	34.29	32.82	....	39.05	42.63	34.88

Month.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	Mean.
December	2.36	3.49	4.32	2.33	1.50	2.96	1.93	2.29	3.23	5.39	......
January	1.70	2.70	1.82	3.99	2.86	3.32	2.41	1.85	2.47	1.99	......
February	2.35	0.55	5.08	2.70	1.86	3.07	2.56	3.59	1.70	0.89	......
March	3.11	4.35	2.84	3.70	2.50	3.81	2.23	1.81	3.49	2.66	......
April	10.46	2.85	2.29	2.27	1.85	3.79	1.44	1.51	1.94	1.99	......
May	3.42	2.32	1.64	1.50	7.60	4.65	4.43	1.82	5.11	4.25	......
Total	23.40	16.26	17.99	16.49	18.17	21.60	15.00	12.87	17.94	17 17	......
June	4.61	3.90	3.18	4.77	3.34	3.38	3.08	3.25	4.24	5.64	......
July	4.09	2.78	6.30	4.08	5.92	3.29	4.97	3.23	5.75	0.80	......
August	2.56	2.20	6.01	6.01	3.13	2.40	4.34	1.72	3.87	4.67	......
Total	11.26	8.88	15.49	14.86	12.39	9.07	12.39	8.20	13.86	11.11	......
September	3.86	1.97	6.27	6.43	1.86	3.53	4.56	5.30	3.10	2.53	......
October	3.00	1.80	4.08	4.46	4.32	3.26	2.61	4.59	2.11	6.96	......
November	1.46	3.41	2.39	4.68	1.60	2.60	4.28	3.80	2.41	2.67	......
Total	8.32	7.18	12.74	15.57	7.78	9.39	11.45	13.69	7.62	12.16	......
Yearly total	42.98	32.32	46.22	46.92	38.34	40.06	38.84	34.76	39.42	40.44	38.76

a Onondaga Hollow records.

TABLE NO. 39.—*Record of precipitation at Cherry Valley for certain water years, as indicated, from 1827 to 1854, inclusive.*

Month.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1841.
December	a 1.07	3.60	0.15	2.78	4.38	3.05	a2.80	3.70	2.52	1.26	3.51	b2.16
January	5.54	1.67	6.33	2.78	3.87	......	2.89	1.75	3.24	5.01	......	3.33
February	7.00	1.56	4.26	0.76	3.41	......	1.93	1.69	1.46	3.20	......	0.84
March	2.65	1.22	4.28	4.85	2.64	......	1.56	2.65	2.10	1.22	......	3.31
April	4.22	2.34	2.02	2.01	6.23	......	0.95	4.13	3.43	2.35	......	4.45
May	1.85	2.95	4.98	3.34	4.20	......	8.39	4.58	1.61	2.80	......	2.15
Total	22.33	13.34	22.02	16.52	24.73	......	18.52	18.50	14.36	15.84	......	16.24
June	4.93	5.21	3.91	6.14	4.58	......	3.41	3.91	6.92	5.68	......	4.05
July	6.22	5.77	2.96	6.11	4.02	......	6.89	2.81	3.71	2.97	......	3.30
August	5.98	2.15	2.05	1.46	3.95	......	2.82	1.45	5.17	2.46	......	2.57
Total	17.13	13.13	8.92	13.71	12.55	......	13.12	8.17	15.80	11.11	......	9.92
September	5.78	5.53	4.29	3.97	3.97	......	4.10	3.26	1.76	2.74	......	3.25
October	4.81	2.07	3.28	3.88	5.40	......	4.88	3.67	1.78	4.60	......	2.25
November	1.67	3.77	3.26	5.37	3.72	......	2.49	1.37	2.44	1.52	......	4.12
Total	12.26	11.37	10.83	13.22	13.09	......	11.47	8.30	5.98	8.86	......	9.62
Yearly total	51.72	37.84	41.77	43.45	50.37	......	43.11	34.97	36.14	35.81	......	35.78

Month.	1842.	1843.	1844.	1845.	1846.	1850.	1851.	1852.	1853.	1854.	Mean.
December	4.65	3.93	2.55	0.81	1.35	......	5.53	......	6.20	......	......
January	2.07	1.85	2.55	0.98	......	......	0.78	......	......	......	......
February	4.91	2.14	0.87	3.71	......	......	3.19	......	......	......	......
March	3.88	5.57	2.85	3.02	......	......	0.94	3.47	......	......	......
April	3.03	3.45	1.70	3.02	......	......	......	4.01	......	......	......
May	1.80	2.72	7.30	2.75	......	......	......	2.90	4.07	2.68	......
Total	20.34	19.66	17.82	14.29	......	......	......	......	......	......	......
June	3.93	5.01	2.53	3.66	......	......	......	2.47	1.42	4.34	......
July	4.18	4.36	5.71	3.05	......	......	......	1.81	2.68	......	......
August	4.54	5.27	2.46	2.44	......	......	......	3.11	......	......	......
Total	12.65	14.64	10.70	9.15	......	......	......	......	......	......	......
September	6.91	2.70	2.35	4.36	......	......	......	0.94	1.63	......	......
October	3.73	4.87	2.14	3.62	......	4.55	......	2.64	4.17	......	......
November	3.52	3.63	2.97	4.46	......	3.14	......	3.66	3.70	......	......
Total	14.16	11.20	7.46	12.44	......	......	......	......	......	......	......
Yearly total	47.15	45.50	35.98	35.88	......	......	......	......	......	......	41.10

[a] Hartwick record.

[b] Mean of—

Utica	3.09
Fairfield	1.05
Oxford	2.35
3)	6.48
	2.16

TABLE NO. 40.—*Record of precipitation at Clinton for certain water years, as indicated, from 1851 to 1865, inclusive.*

Month.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.
December	*a* 4.74	3.08	5.16	1.49	2.65	3.81	3.03	4.78
January	1.46	2.86	2.46	2.66	4.11	1.20	1.46	2.43
February	3.86	2.48	*a* 3.08	2.99	1.10	1.30	2.96	2.01
March	1.65	3.55	2.78	4.30	0.80	2.32	3.63	1.41
April	*a* 3.72	3.91	3.70	8.19	0.42	2.41	9.18	4.37
May	2.52	4.12	4.61	2.70	2.15	4.82	4.66	4.73
Total	17.95	20.00	21.79	22.33	11.23	15.86	24.92	19.73
June	4.90	3.99	2.75	4.81	8.12	2.65	8.51	4.20
July	5.37	4.36	3.08	2.76	8.03	1.42	4.68	4.18
August	2.94	2.80	4.58	2.60	3.59	3.07	7.15	3.34
Total	13.21	11.15	10.41	10.17	19.74	7.14	20.34	11.72
September	2.77	2.99	6.75	3.92	4.66	3.72	4.40	3.28
October	3.06	5.37	3.30	2.68	7.21	1.17	6.41	4.25
November	4.79	5.66	3.06	2.72	3.89	3.65	3.91	3.94
Total	10.62	14.02	13.11	9.32	15.76	8.54	14.72	11.47
Yearly total	41.78	45.17	45.31	41.82	46.73	31.54	59.98	42.92

Month.	1859.	1860.	1861.	1862.	1863.	1864.	1865.	Mean.
December	3.99	4.58	2.33	*b* 1.44	2.38	4.56	2.38	....
January	3.63	1.23	....	2.90	5.49	2.83	2.42	....
February	1.32	1.02	....	1.80	2.62	1.01	4.65	....
March	3.78	1.80	....	2.40	2.84	1.79	2.32	....
April	5.85	1.72	....	1.46	1.07	2.38	....	....
May	2.28	5.25	....	1.91	2.97	3.73	....	....
Total	20.85	15.60	....	11.91	17.37	16.30	....	....
June	6.75	3.69	....	2.26	1.68	1.15	....	....
July	4.73	6.12	....	3.06	5.46	2.39	....	....
August	3.33	4.20	....	1.52	5.84	7.56	....	....
Total	14.81	14.01	....	6.84	12.98	11.10	....	....
September	5.36	4.22	....	1.49	2.47	2.72	....	....
October	2.69	5.77	....	4.65	2.97	3.55	....	....
November	4.65	6.08	....	4.84	2.75	3.64	....	....
Total	12.70	16.07	....	10.98	8.19	9.91	....	....
Yearly total	48.36	45.68	....	29.73	38.54	37.31	....	42.68

a Mean of—

Oxford	4.46	4.28	4.13
Pompey	4.22	3.16	2.04
Cherry Valley	5.53	....	....
	3) 14.21	2) 7.44	6.17
	4.74	3.72	3.08

b Mean of—

Cooperstown	1.78
Mexico	1.10
	2) 2.88
	1.44

TABLE NO. 41.—*Record of precipitation at Constableville for the water years 1889 to 1893, inclusive.*

Month.	1889.	1890.	1891.	1892.	1893.	Mean.
December	*a*2.68	6.14	2.72	5.39	1.15	....
January	4.05	7.24	5.84	6.80	*b*3.78	....
February	5.46	5.93	8.24	3.48	4.19	....
March	1.21	3.02	5.12	4.37	1.87	....
April	1.94	3.76	2.95	2.18	2.62	....
May	3.06	8.43	1.63	6.64	4.87	....
Total	18.40	34.52	26.50	28.95	18.48	....
June	5.86	3.90	3.23	*b*5.43	2.93	....
July	7.13	8.45	5.76	5.45	2.04	....
August	1.65	5.56	4.34	8.19	6.00	....
Total	14.64	17.91	13.33	19.07	10.97	....
September	3.15	8.53	1.75	3.06	....	....
October	4.58	6.05	3.12	1.83	....	....
November	6.26	4.72	6.47	2.70	....	....
Total	13.99	19.30	11.34	7.59	....	....
Yearly total	47.03	71.73	51.17	55.61	....	56.38

a Mean of—

Utica	3.12
Palermo	2.25
	2)5.37
	2.68

b Turin record.

TABLE NO. 42.—*Record of precipitation at Cooperstown for the water years 1854 to 1898, inclusive.*

Month.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	1861.	1862.	1863.	1864.	1865.
December	*a*1.38	2.30	4.13	2.65	3.32	2.82	3.02	1.45	1.78	1.34	3.94	3.27
January	2.10	3.34	1.12	2.36	1.77	2.53	0.32	2.00	3.66	4.04	1.68	2.23
February	3.46	1.23	0.60	2.15	1.66	0.94	0.71	1.30	1.73	2.32	0.85	1.60
March	3.33	0.61	1.54	1.83	0.97	3.95	1.05	2.71	3.80	2.92	2.29	3.45
April	7.12	4.15	3.42	5.53	2.66	4.19	1.55	3.92	1.90	0.92	2.19	2.19
May	3.11	2.20	4.44	5.63	4.65	1.97	1.83	3.14	1.40	6.28	3.40	4.92
Total	20.50	13.83	15.25	20.15	15.03	16.40	8.48	14.52	14.27	17.82	14.35	17.66
June	2.85	7.76	2.19	7.80	8.08	5.39	3.15	1.97	6.13	3.43	1.00	2.39
July	2.25	4.84	2.82	5.20	7.11	4.47	6.89	7.36	3.37	7.92	1.79	3.70
August	1.43	6.73	9.46	6.79	3.43	4.65	7.07	4.64	3.28	5.84	5.81	1.02
Total	6.53	19.33	14.47	19.79	18.62	14.51	17.11	13.97	12.78	17.19	8.60	7.11
September	4.13	2.24	3.45	2.45	2.43	5.41	2.69	3.57	2.39	4.33	2.88	4.86
October	3.11	5.28	0.88	6.65	4.46	1.66	2.80	5.16	4.80	1.74	2.39	3.80
November	2.71	3.56	2.00	2.29	5.38	3.18	4.22	3.13	4.17	3.59	2.37	3.34
Total	9.95	11.08	6.33	11.39	12.27	10.25	9.71	11.86	11.36	9.66	7.64	12.00
Yearly total	36.98	44.24	36.05	51.33	45.92	41.16	35.30	40.35	38.41	44.67	30.59	36.77

a Mean of—

Oxford	1.26
Clinton	1.49
	2)2.75
	1.38

TABLE NO. 42.—*Record of precipitation at Cooperstown for the water years 1854 to 1898, inclusive*—Continued.

Month.	1866.	1867.	1868.	1869.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.
December	1.94	2.50	1.63	1.90	3.69	1.96	1.76	2.17	2.86	1.27	1.48	2.26
January	0.97	0.85	2.24	4.31	4.16	1.14	0.52	3.01	3.70	2.16	4.11	2.58
February	3.45	1.85	0.93	2.67	3.72	1.94	1.58	1.67	3.30	1.19	4.13	0.63
March	1.70	1.67	2.74	2.88	2.53	5.29	0.80	4.00	1.35	3.19	3.36	3.37
April	1.02	3.54	2.43	3.68	2.36	2.66	1.17	3.09	4.10	2.55	1.68	1.77
May	2.00	7.38	5.76	5.49	1.94	3.18	4.16	1.65	1.68	2.36	1.97	1.27
Total	11.08	17.79	15.73	20.93	18.40	16.17	9.99	15.59	16.99	12.72	16.73	11.88
June	4.27	2.15	4.94	4.31	0.95	5.25	7.31	1.94	7.00	5.24	4.93	4.71
July	3.57	3.35	0.89	4.57	4.14	4.64	5.84	5.26	5.34	3.24	5.13	6.78
August	2.24	5.40	2.47	3.02	2.74	4.50	4.45	5.52	1.06	5.85	0.63	2.84
Total	10.08	10.90	8.30	11.90	7.83	14.39	17.60	12.72	13.40	14.33	10.69	14.33
September	5.04	3.36	5.74	3.31	2.80	1.17	3.32	3.41	2.25	2.52	5.79	1.92
October	1.32	3.68	2.10	6.10	3.80	1.97	3.62	5.62	2.60	4.96	1.73	4.42
November	4.25	1.52	5.28	1.91	1.92	2.88	1.98	4.16	2.85	3.00	1.45	3.22
Tctal	10.61	8.56	13.12	11.32	8.52	6.02	8.92	13.19	7.70	10.48	8.97	9.56
Yearly total	31.77	37.25	37.15	44.15	34.75	36.58	36.51	41.50	38.09	37.53	36.39	35.77

Month.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
December	0.97	3.80	4.26	1.23	6.02	2.02	1.93	4.00	2.15	2.00	3.43
January	3.33	2.35	4.26	2.54	2.67	1.49	3.17	3.00	1.83	3.23	2.47
February	1.80	2.91	2.26	1.53	3.17	3.74	3.16	2.46	1.86	5.21	1.58
March	2.87	2.01	1.71	3.05	2.48	1.69	4.48	0.55	2.92	4.32	3.34
April	2.47	3.48	2.76	0.98	1.30	1.68	1.20	1.94	1.86	2.42	3.05
May	4.20	0.36	3.32	3.00	3.98	3.15	3.97	3.39	2.50	2.83	2.76
Total	15.64	14.91	18.57	12.33	19.62	13.77	17.91	15.34	13.12	20.01	16.63
June	4.25	4.16	2.78	3.59	4.88	4.62	2.16	3.59	3.01	2.56	4.32
July	3.57	2.82	4.49	3.07	2.44	4.77	3.01	3.00	3.02	2.85	1.52
August	2.93	1.43	2.78	0.72	0.91	3.21	2.46	9.08	2.56	3.31	4.95
Total	10.75	8.44	10.05	7.38	8.23	12.60	7.63	15.67	8.59	8.75	10.79
September	3.29	2.12	3.17	1.43	3.68	5.05	1.29	1.96	4.12	1.42	3.97
October	3.29	1.26	2.42	4.89	1.48	2.96	3.31	4.19	2.54	1.19	4.09
November	3.18	3.00	3.02	3.24	1.79	1.76	2.86	3.05	4.72	3.15	3.09
Total	9.76	6.38	8.61	9.56	6.95	9.77	7.46	9.20	11.38	5.76	11.15
Yearly total	36.15	29.73	37.23	29.27	34.80	36.14	33.00	40.21	33.09	34.52	38.57

Month.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	3.30	2.68	4.33	4.96	1.53	4.02	2.33	3.89	1.21	4.64	......
January	2.22	4.39	5.54	4.99	1.89	2.84	2.34	1.48	1.72	4.90	......
February	1.79	2.91	4.76	2.23	4.99	2.09	1.43	5.36	2.06	2.93	......
March	1.76	4.17	2.60	3.43	2.13	1.92	1.93	4.74	3.31	2.14	......
April	2.93	2.86	2.22	1.38	2.96	2.54	2.89	1.25	3.65	4.00	......
May	3.96	8.84	2.16	7.82	6.74	5.29	2.44	2.33	5.21	4.70	......
Total	15.96	25.85	21.61	24.81	20.24	18.70	13.36	19.05	17.16	23.31	......
June	5.95	4.89	1.98	4.86	2.20	2.62	2.18	4.70	5.22	3.80	......
July	5.61	3.39	5.02	7.80	4.85	3.41	3.80	4.60	4.86	3.02	......
August	2.13	6.01	4.26	7.96	7.59	1.88	7.15	3.49	6.60	9.75	......
Total	13.69	14.29	11.26	20.62	14.64	7.91	13.13	12.79	16.68	16.57	......
September	3.87	7.24	1.41	3.57	4.03	5.55	2.86	4.33	3.40	4.20	......
October	2.17	5.91	3.01	1.79	1.27	4.73	2.17	2.23	0.64	5.36	......
November	3.50	3.17	3.15	3.19	2.20	2.72	3.65	3.56	5.21	4.64	......
Total	9.54	16.32	7.57	8.55	7.50	13.00	8.68	10.12	9.25	14.20	......
Yearly total	39.19	56.46	40.44	53.98	42.38	39.61	35.17	41.96	43.09	54.08	39.07

Table No. 43.—*Record of precipitation at Cortland for certain water years, as indicated, from 1850 to 1898, inclusive.*

Month.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.
December	......	4.39	3.01	3.98	1.76	3.13	3.91	2.30	3.29	4.93	4.06
January	......	1.30	2.08	2.57	2.60	4.23	2.07	3.02	2.35	2.94	1.38
February	......	5.77	1.89	4.49	4.46	2.20	1.02	2.05	2.22	1.82	1.04
March	......	1.94	3.38	2.90	3.34	1.43	1.99	2.58	1.17	4.71	4.01
April	......	4.22	3.67	4.41	5.84	5.35	2.85	6.78	2.70	5.54	2.70
May	......	5.41	4.71	4.69	2.33	4.01	4.06	4.38	5.01	3.85	3.53
Total	......	23.03	18.74	23.04	20.33	20.35	15.90	21.11	16.74	23.79	16.72
June	......	4.94	3.78	3.94	3.31	8.69	3.41	12.55	3.28	5.54	5.56
July	......	5.51	7.52	2.28	2.19	6.27	3.85	2.39	5.09	5.07	6.43
August	......	2.67	3.40	3.59	2.19	2.80	3.65	5.40	3.69	5.49	4.66
Total	......	13.12	14.70	9.81	7.69	17.76	10.91	20.34	12.06	16.10	16.65
September	6.00	2.09	3.09	4.72	3.91	2.67	4.17	4.45	3.62	5.12	4.13
October	6.63	2.16	4.30	4.56	3.73	4.11	2.08	4.88	3.33	1.65	3.46
November	4.20	5.60	4.56	3.15	3.07	3.39	2.98	3.48	3.93	3.77	3.75
Total	16.83	9.85	11.95	12.43	10.71	10.17	9.23	12.81	10.88	10.54	11.34
Yearly total	......	46.00	45.39	45.28	38.73	48.28	36.04	54.26	39.68	50.43	44.71

Month.	1861.	1862.	1863.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	2.42	1.95	2.81	......	1.08	2.35	1.70	3.86	2.32	3.00	......
January	2.86	4.01	5.02	......	1.54	2.75	2.95	1.86	2.68	4.74	......
February	3.30	2.92	3.02	......	2.90	2.01	0.97	4.50	1.11	2.39	......
March	3.01	4.92	2.20	......	2.22	1.59	1.36	4.54	1.55	2.07	......
April	4.99	1.78	2.66	......	3.12	2.75	1.62	0.93	0.68	3.43	......
May	5.02	1.79	5.13	7.96	6.29	6.31	2.60	2.73	4.23	4.96	......
Total	21.60	17.37	20.84	......	17.15	17.76	11.20	18.42	12.57	20.59	......
June	5.88	4.64	5.46	5.28	1.45	4.60	2.91	3.44	3.81	2.80	......
July	1.79	7.00	8.45	6.44	4.57	2.53	4.53	4.36	4.46	3.14	......
August	5.36	2.58	*a* 6.44	4.77	4.37	1.45	5.55	2.15	2.07	9.44	......
Total	13.03	14.22	20.35	15.49	10.39	8.58	12.99	9.95	10.34	15.38	......
September	6.56	1.52	*a* 0.64	1.58	4.17	4.44	2.36	3.70	3.13	3.46	......
October	5.47	6.73	3.81	2.31	3.73	4.39	0.85	3.32	0.71	6.27	......
November	2.32	3.34	*a* 3.83	3.28	1.94	1.98	3.05	3.17	3.55	3.10	......
Total	14.35	11.59	8.28	7.17	9.84	10.81	6.26	10.19	7.39	12.83	......
Yearly total	48.98	43.18	49.47	......	37.38	37.15	30.45	38.56	30.30	48.80	42.79

a Geneva record.

TABLE No. 44.—*Record of precipitation at De Kalb Junction for the water years 1890 to 1898, inclusive.*

Month.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	....	1.85	3.31	1.77	5.01	1.90	5.38	0.91	2.84	....
January	....	2.90	3.08	1.36	2.95	2.50	1.40	2.47	4.76	....
February	....	3.30	1.61	2.21	1.56	1.01	3.81	1.02	1.85	....
March	....	4.40	2.89	1.29	2.39	1.16	3.30	3.19	1.46	....
April	....	2.05	1.53	*a*2.71	1.37	2.63	1.28	2.81	1.22	....
May	....	1.47	4.67	6.38	4.24	2.36	1.84	3.14	3.62	....
Total	....	16.06	17.09	15.72	17.52	11.56	17.01	13.54	15.75	....
June	3.99	2.00	5.72	2.37	2.28	1.88	5.31	2.65	3.18	....
July	2.93	5.73	5.40	5.44	3.41	3.68	4.56	4.84	2.80	....
August	6.27	6.26	9.82	9.14	0.91	4.84	3.03	2.46	4.24	....
Total	13.19	13.99	20.94	16.95	6.60	10.40	12.90	9.95	10.22	....
September	5.87	2.65	3.23	3.13	3.00	4.50	5.61	2.37	6.08	....
October	2.30	3.14	1.69	1.36	3.47	0.82	1.08	0.86	4.33	....
November	3.72	4.76	4.86	2.55	2.59	5.34	2.76	4.72	2.08	....
Total	11.89	10.55	9.78	7.04	9.66	10.66	9.45	7.95	12.46	....
Yearly total	....	40.60	47.81	39.71	33.78	32.62	39.26	31.44	38.43	37.97

a Mean of—

Canton	2.29
North Hammond	3.52
Ogdensburg	1.95
Potsdam	3.07
	4)10.83
	2.71

TABLE No. 45.—*Record of precipitation at Demster for the water years 1890 to 1897, inclusive.*

Month.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	Mean.
December	....	2.83	6.34	2.97	3.05	2.48	4.82	3.82	....
January	....	2.97	1.74	2.25	3.55	1.80	1.61	4.96	....
February	....	3.79	2.47	2.49	3.16	1.48	4.76	1.20	....
March	....	3.80	1.80	1.22	1.93	1.22	3.53	....	....
April	....	1.88	1.36	3.63	1.95	2.34	1.13	....	....
May	....	1.40	5.00	5.89	7.64	3.04	2.45	....	....
Total	....	16.67	18.71	18.45	21.28	12.38	18.30	....	....
June	2.48	1.97	7.44	3.77	4.16	2.11	2.33	....	....
July	3.84	5.70	5.41	1.84	2.60	2.54	5.97	....	....
August	2.82	3.74	6.18	4.80	0.94	3.77	2.47	....	....
Total	9.14	11.41	19.03	10.41	7.70	8.42	10.77	....	....
September	9.47	1.80	2.16	3.31	3.86	2.67	4.31	....	....
October	4.80	3.88	3.53	2.54	5.21	2.45	2.31	....	....
November	4.00	4.22	4.80	3.06	3.75	4.08	3.33	....	....
Total	18.27	9.90	10.49	8.91	12.82	9.20	9.95	....	....
Yearly total	....	37.98	48.23	37.77	41.80	29.98	39.02	....	39.18

TABLE NO. 46.—*Record of precipitation at Depauville for the water years 1865 to 1876, inclusive.*

Month.	1865.	1866.	1867.	1868.	1869.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	Mean.
December	......	4.35	4.07	2.41	2.90	4.38	3.57	4.28	4.65	6.65	1.45	2.16	......
January	3.60	3.32	2.08	3.35	1.86	4.95	2.25	1.68	4.72	6.17	2.44	4.35	......
February	......	3.98	3.74	3.51	5.01	4.42	2.15	2.67	1.63	4.16	1.76	2.43	......
March	......	3.20	3.24	4.47	4.95	4.68	4.65	2.73	6.98	3.38	1.59	......	......
April	......	2.29	3.95	3.25	1.10	1.15	3.70	1.60	3.41	3.30	1.37	......	......
May	......	3.74	5.90	5.48	4.08	1.34	1.82	4.05	1.98	2.91	4.08	......	......
Total	......	20.88	22.98	22.47	19.90	20.92	18.14	16.41	23.37	26.57	12.69	......	......
June	......	4.08	2.22	2.04	3.09	2.27	2.80	2.77	2.35	4.54	2.22	......	......
July	......	3.01	2.18	1.00	3.65	1.58	2.68	2.30	5.55	4.69	1.58	......	......
August	......	5.30	2.05	3.43	2.75	1.37	4.40	3.15	3.20	1.23	3.70	......	......
Total	......	12.39	6.45	6.47	9.49	5.22	9.88	8.22	11.10	10.46	7.50	......	......
September	4.10	6.42	0.57	4.45	6.95	4.57	3.05	4.85	3.10	3.75	4.10	......	......
October	7.00	3.44	3.94	3.60	7.10	3.98	2.00	6.92	7.05	5.27	2.21	......	......
November	5.30	5.17	2.31	6.09	5.42	1.95	3.83	4.75	2.92	4.43	1.99	......	......
Total	16.40	15.03	6.82	14.14	19.47	10.50	8.88	16.52	13.07	13.45	8.30	......	......
Yearly total	......	48.30	36.25	43.08	48.86	36.64	36.90	41.15	47.54	50.48	28.49	......	41.77

TABLE NO. 47.—*Record of precipitation at Elmira for certain water years, as indicated, from 1851 to 1898, inclusive.*

Month.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	1861.	1862.
December	......	3.10	......	0.82	2.80	2.27	1.52	2.28	4.50	3.26	1.48	4.55
January	......	......	......	1.84	1.82	4.72	3.66	0.72	1.70	2.35	1.88	......
February	......	......	......	1.90	2.60	0.25	1.63	1.48	2.07	2.50	2.00	2.00
March	......	2.32	......	2.57	1.19	1.21	1.10	0.75	3.82	5.99	1.57	......
April	3.28	3.93	......	5.49	2.51	3.77	6.51	1.94	2.85	4.81	3.85	......
May	2.37	2.53	......	2.82	3.15	3.28	6.32	5.91	2.60	7.73	......	......
Total	......	......	......	15.48	14.07	15.50	20.74	13.08	17.54	26.64	......	......
June	......	3.18	3.13	5.10	5.75	6.60	7.02	2.20	5.00	4.10	......	......
July	4.23	4.33	1.40	3.12	4.80	1.70	1.60	2.96	2.50	3.90	......	......
August	1.67	2.03	3.18	1.60	3.20	3.19	2.10	2.45	5.40	6.45	......	......
Total	......	9.54	7.71	9.82	13.75	11.49	10.72	7.61	12.90	14.45	......	......
September	2.29	1.86	2.42	3.25	0.63	2.28	3.40	2.00	3.19	2.50	......	......
October	......	1.78	1.98	2.18	2.69	2.20	4.33	2.50	1.68	5.20	7.00	......
November	2.58	......	1.95	1.00	2.30	1.90	2.75	2.40	2.20	3.70	0.31	......
Total	......	......	6.35	6.43	5.62	6.38	10.48	6.90	7.07	11.40	......	......
Yearly total	......	......	......	31.73	33.44	33.37	41.94	27.59	37.51	52.49	......	......

TABLE NO. 47.—*Record of precipitation at Elmira for certain water years, as indicated, from 1851 to 1898, inclusive*—Continued.

Month.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	*a* 3.62	*b* 2.38	2.54	3.06	*c* 0.59	*d* 2.26	2.89	2.70	0.61	1.60	......
January	*b* 2.35	1.84	2.33	3.01	0.62	2.73	2.70	1.56	1.40	2.45	......
February	0.75	1.68	2.19	*c* 1.55	1.61	1.89	0.60	3.40	0.93	1.45	......
March	0.25	3.48	1.98	2.96	2.05	1.05	1.37	3.22	2.41	2.53	......
April	2.36	3.91	1.73	1.01	3.55	4.42	1.56	0.77	2.30	2.84	......
May	3.51	6.04	0.50	5.30	6.84	7.65	3.03	3.14	5.56	4.29	......
Total	12.84	19.33	11.27	16.89	15.26	20.00	12.15	14.79	13.21	15.16	......
June	5.19	4.67	4.57	4.11	3.62	1.94	3.51	3.31	1.76	3.43	......
July	3.98	2.51	2.13	3.39	3.89	1.62	2.34	5.55	3.23	2.24	......
August	*b* 1.23	5.75	3.72	3.28	5.54	1.23	4.04	0.94	3.70	4.70	......
Total	10.40	12.93	10.42	10.78	13.05	4.79	9.89	9.80	8.69	10.37	......
September	1.97	6.14	3.25	1.18	3.72	5.16	1.89	2.73	3.70	1.78	......
October	3.51	3.84	3.41	1.30	2.66	4.21	0.78	4.86	0.65	4.49	......
November	4.19	0.86	1.31	*c* 3.09	*d* 1.59	1.28	1.25	1.40	2.89	2.24	......
Total	9.67	10.84	7.97	5.57	7.97	10.65	3.92	8.99	7.24	8.51	......
Yearly total	32.91	43.10	29.66	33.24	36.28	35.44	25.96	33.58	29.14	34.04	34.79

a Mean of—

Auburn	3.94
Cooperstown	3.30
	2)7.24
	3.62

b Factoryville record.

c Mean of—

Addison	1.58	3.46	0.48
Waverly	1.53	2.71	0.70
	2)3.11	6.17	1.18
	1.55	3.09	0.59

d Pine City record.

TABLE NO. 48.—*Record of precipitation at Fairfield for certain water years, as indicated, from 1828 to 1849, inclusive.*

Month.	1828.	1829.	1831.	1832.	1833.	1835.	1836.	1837.	1838.	1839.	1840.
December	*a* 3.00	0.00	*a* 2.84	1.25	1.80	*b* 2.12	0.81	1.74	1.60	0.33	1.25
January	2.13	......	1.54	2.90	......	1.82	3.96	1.58	0.38	3.45	1.32
February	2.90	......	1.10	1.60	......	2.25	3.37	0.34	0.04	0.78	0.25
March	2.48	......	1.52	1.99	......	1.63	1.89	3.22	0.40	0.90	1.20
April	2.76	......	1.80	2.39	......	1.68	2.74	1.10	0.50	2.10	5.10
May	2.58	......	1.80	3.02	......	1.10	4.26	2.92	3.65	3.55	3.92
Total	15.85	......	10.60	13.15	......	10.60	17.03	10.90	6.57	11.11	13.04
June	5.48	......	3.40	2.15	......	6.38	6.25	5.10	3.55	5.55	4.12
July	10.89	......	3.18	2.67	......	4.65	2.42	3.85	2.33	5.70	4.67
August	5.46	......	2.90	5.14	......	6.79	1.61	3.17	7.61	1.35	4.62
Total	21.83	......	9.48	9.96	......	17.82	10.28	12.12	13.49	12.60	13.41
September	4.23	......	2.10	2.29	......	3.01	1.37	2.78	2.30	3.00	4.48
October	2.38	......	1.24	4.47	......	4.63	2.52	5.74	3.15	0.55	4.98
November	4.22	......	1.90	1.80	......	1.42	2.58	1.15	3.42	1.70	1.63
Total	10.83	......	5.24	8.56	......	9.06	6.47	9.67	8.87	5.25	11.09
Yearly total	48.51	......	25.32	31.67	......	37.48	33.78	32.69	28.93	28.96	37.54

a Utica record.

b Johnstown record

Johnstown record	2.35
Utica	1.89
	2)4.24
	2.12

TABLE NO. 48.—*Record of precipitation at Fairfield for certain water years, as indicated, from 1828 to 1849, inclusive*—Continued.

Month.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	Mean.
December	1.04	3.60	4.05	2.13	2.12	5.97	*a*3.25	6.42	9.91	......
January	5.10	2.83	2.68	2.91	4.11	....	3.60	2.41	3.09	2.69
February	1.03	6.35	0.96	3.15	3.89	....	3.89	1.21	1.86	2.06
March	3.33	5.00	2.57	2.43	2.43	....	3.04	4.24	1.85	2.36
April	3.70	3.97	2.68	1.70	3.28	....	2.15	2.78	2.62	2.53
May	1.58	2.83	1.07	7.39	3.54	....	2.64	3.00	2.80	3.04
Total	15.78	24.58	14.01	19.71	19.37	....	18.57	20.06	22.13	......
June	3.81	4.61	4.48	2.99	4.30	....	4.87	2.20	3.73	4.29
July	3.87	6.14	4.41	4.47	2.19	....	2.84	6.40	0.92	4.21
August	2.62	2.90	3.81	4.04	0.94	....	2.55	2.71	3.95	3.66
Total	10.30	13.65	12.70	11.50	7.43	....	10.26	11.31	8.60	12.16
September	3.44	6.58	2.06	2.57	3.94	....	3.76	2.66	1.83	3.08
October	1.41	3.58	4.47	3.78	2.31	....	4.53	2.59	8.25	3.56
November	2.00	2.72	4.59	2.00	3.84	....	2.26	0.40	4.22	2.46
Total	6.85	12.88	11.12	8.35	10.09	....	10.55	5.65	14.30	9.11
Yearly total	32.93	51.11	37.83	39.56	36.89	....	39.38	37.02	45.03	36.74

a Utica record.

b Johnstown record.... 2.35
Utica.................. 1.89
2)4.24
2.12

TABLE NO. 49.—*Record of precipitation at Fleming for the water years 1890 to 1898, inclusive.*

Month.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	*a*3.07	1.80	4.33	0.20	1.36	2.87	3.36	0.40	1.92	......
January	5.34	0.85	1.65	0.66	1.80	*b*1.81	1.80	1.90	1.33	......
February	2.74	1.70	1.39	1.30	*b*2.64	*b*0.56	4.29	1.40	1.11	......
March	2.39	2.50	1.61	1.25	1.15	0.60	3.95	2.19	1.42	......
April	2.45	1.01	0.75	2.62	*b*4.57	1.40	1.40	2.21	2.29	......
May	7.01	0.50	5.51	5.61	5.07	3.50	2.42	2.17	3.18	......
Total	23.00	8.36	15.24	11.64	16.59	10.74	17.22	10.27	11.25	......
June	6.72	2.33	4.75	1.32	5.23	3.11	2.41	3.96	2.48	......
July	1.52	1.51	3.30	3.67	2.82	4.11	4.29	3.86	1.97	......
August	5.05	3.27	5.72	2.01	2.06	3.03	2.72	2.52	4.15	......
Total	13.29	7.11	13.77	7.00	10.11	10.25	9.42	10.34	8.60	......
September	6.02	2.05	1.42	2.36	5.77	1.87	4.93	3.46	3.55	......
October	4.45	4.36	2.40	0.98	5.04	1.08	3.10	0.80	3.64	......
November	1.93	2.23	1.60	1.45	1.78	2.90	2.88	2.68	2.21	......
Total	12.40	8.64	5.42	4.79	12.59	5.85	10.91	6.94	9.40	......
Yearly total	48.69	24.11	34.43	23.43	39.29	26.84	37.55	27.55	29.25	32.35

a Auburn record.

b Romulus record.

TABLE NO. 50.—*Record of precipitation at Friendship for the water years 1893 to 1897, inclusive.*

Month.	1893.	1894.	1895.	1896.	1897.	Mean.
December	*a* 1.21	3.51	2.15	3.35	1.40	....
January	1.16	4.26	3.03	2.03	2.29	....
February	4.96	3.17	1.34	3.23	1.56	....
March	2.83	1.73	1.01	3.45	3.59	....
April	4.34	5.81	1.96	1.58	2.77	....
May	5.70	9.19	2.39	3.09	2.65	....
Total	19.70	27.67	11.88	16.73	14.26	....
June	2.04	3.37	4.91	3.22	2.93	....
July	2.01	3.90	2.72	4.54	4.47	....
August	5.33	2.41	3.74	1.83	*a* 3.26	....
Total	9.38	9.77	11.37	9.59	10.66	....
September	3.65	6.89	3.02	5.65	*a* 2.06	....
October	3.07	3.50	1.44	4.03	*a* 0.70	....
November	2.12	1.92	3.44	2.29	*a* 4.69	....
Total	8.84	12.31	7.90	11.97	7.45	....
Yearly total	37.92	49.75	31.15	38.29	32.37	37.90

a Bolivar record.

TABLE NO. 51.—*Record of precipitation at Geneva for certain water years, as indicated, from 1850 to 1860, inclusive.*

Month.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.
December	......	6.46	0.96	3.44	......	2.49	2.69	2.15	2.04	2.80	2.88
January	......	1.34	0.57	1.10	......	2.49	2.32	0.87	1.65	0.85	1.47
February	......	2.49	1.30	3.26	......	0.81	0.17	1.83	1.17	1.09	0.56
March	......	......	3.54	1.09	1.95	0.76	0.78	1.38	1.11	3.50	2.50
April	......	......	1.35	2.87	5.20	2.81	2.27	4.56	2.81	4.89	1.99
May	......	......	3.60	2.86	2.21	3.79	2.01	3.42	4.47	2.57	1.51
Total	......	......	11.32	14.62	......	13.15	10.24	14.21	13.25	15.70	10.91
June	......	2.61	3.56	1.88	2.48	3.72	3.92	8.14	3.86	3.34	3.02
July	......	3.32	2.12	......	0.89	4.79	5.09	3.21	3.03	1.70	4.63
August	......	1.81	*a* 1.68	......	0.77	2.75	1.30	4.26	3.79	4.49	3.27
Total	......	7.74	7.36	......	4.14	11.26	10.31	15.61	10.68	9.53	10.92
September	......	......	1.16	......	3.27	2.85	2.66	1.87	3.05	3.18	3.52
October	......	1.60	2.77	......	2.08	4.30	2.14	6.30	1.27	2.02	2.91
November	4.12	3.14	3.44	......	1.55	1.34	1.59	4.68	3.05	1.48	3.70
Total	......	......	7.37	......	6.90	8.49	6.39	12.84	7.37	6.68	10.13
Yearly total	......	......	26.05	......	......	32.90	26.94	42.67	31.30	31.91	31.96

a Geneva Falls record.

Table No. 51.—*Record of precipitation at Geneva for certain water years, as indicated, from 1850 to 1893, inclusive*—Continued

Month.	1861.	1862.	1863.	1864.	1865.	1866.	1867.	1868.	1882.	1883.	1884.
December	1.78	1.26	1.78	a2.32	1.45	1.08	1.76	0.70	....	0.55	0.73
January	1.58	3.64	6.78	0.63	2.54	0.92	1.30	1.92	....	0.48	1.83
February	2.54	2.06	1.46	0.53	2.48	1.08	1.04	1.09	....	1.44	2.01
March	1.28	5.23	0.88	1.26	2.05	1.61	0.66	2.46	....	0.88	2.54
April	3.30	2.02	1.97	4.28	2.66	2.16	3.91	2.38	....	1.58	0.83
May	3.31	1.89	2.46	6.31	3.92	2.27	6.59	3.74	....	4.45	2.49
Total	13.79	16.10	15.33	15.33	15.10	9.02	15.26	12.29	....	9.38	10.43
June	0.98	5.52	3.05	1.49	3.56	4.42	2.05	3.12	3.69	4.12	2.01
July	4.38	3,67	4.77	1.29	2.90	2.07	2.64	0.85	2.42	2.98	2.33
August	2.92	2.56	6.44	7.14	1.94	3.22	0.96	1.29	2.37	3.47	1.44
Total	8.28	11.75	14.26	9.92	8.40	9.71	5.65	5.26	8.48	10.57	5.78
September	5.83	1.48	0.64	1.97	4.86	4.58	0.09	....	1.25	2.12	3.17
October	3.77	4.97	1.80	4.18	3.43	1.83	1.50	....	0.62	2.10	1.67
November	1.06	2.25	3.83	2.44	1.73	2.89	0.33	....	1.22	1.54	1.01
Total	10.66	8.70	6.27	8.59	10.02	9.30	1.92	....	3.09	5.76	5.85
Yearly total	32.73	30.55	35.86	33.84	33.52	28.03	22.83	....	....	25.71	22.06

Month.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	Mean.
December	0.97	0.76	1.24	1.35	1.24	1.62	2.55	3.67	1.31	....
January	1.07	1.13	0.18	0.78	2.90	2.16	2.43	3.32	1.54	....
February	0.61	0.95	2.97	1.04	0.25	1.45	3.04	2.69	2.98	....
March	0.12	1.13	0.48	1.43	0.66	2.16	4.35	2.80	1.56	....
April	1.26	4.13	1.37	3.09	3.28	2.20	1.95	1.28	3.94	....
May	1.58	1.92	0.46	2.79	1.21	5.49	0.50	5.03	5.11	....
Total	5.61	10.02	6.70	10.48	9.63	15.08	14.82	18.79	16.44	....
June	2.49	2.92	2.01	3.88	7.47	5.26	3.76	5.47	3.13	....
July	4.64	4.41	6.37	0.90	4.57	1.07	3.78	2.27	3.23	....
August	5.02	2.86	3.03	4.02	1.98	4.34	3.93	5.67	4.53	....
Total	12.15	10.19	11.41	8.89	14.02	10.67	11.47	13.41	10.89	....
September	2.11	2.31	0.75	2.73	2.50	5.81	0.72	1.30	2.54	....
October	2.88	1.39	1.74	3.47	3.32	4.54	3.95	1.50	1.83	....
November	1.36	3.48	1.58	2.02	3.44	2.40	1.68	4.02	b0.56	....
Total	6.35	7.18	4.07	8.22	9.28	12.75	6.35	6.82	4.93	....
Yearly total	24.11	27.39	22.18	27.59	32.91	38.50	32.64	39.02	32.26	30.86

a Mean of—
Utica 2.67
Rochester 1.98
2)4.65
2.32

b Romulus record.

Table No. 52.—*Record of precipitation at Glens Falls for the water years 1879 to 1898, inclusive.*

Month.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.
December	5.60	2.92	1.75	5.86	2.37	2.02	3.95	1.77	2.45	4.79	3.10
January	2.92	2.13	2.75	1.25	3.37	1.87	3.46	3.10	4.45	3.87	4.54
February	2.46	1.50	2.59	1.71	2.02	4.19	1.79	1.91	4.70	3.46	2.38
March	4.32	2.54	2.04	3.17	1.92	4.00	1.34	3.25	2.12	6.04	1.52
April	2.06	2.21	*a*2.16	1.12	1.33	1.58	2.63	2.30	3.08	2.48	1.33
May	0.50	3.43	3.54	2.24	2.06	2.31	3.00	2.63	1.81	3.12	4.32
Total	17.86	14.73	14.83	15.35	13.07	15.97	16.17	14.96	18.61	23.76	17.19
June	3.38	0.62	1.67	3.75	1.63	1.81	4.62	2.25	2.25	1.63	6.23
July	3.00	2.56	2.24	2.06	2.88	2.19	3.55	3.68	7.68	1.37	4.49
August	1.81	1.43	1.24	3.56	0.50	3.31	7.42	2.69	2.55	6.55	2.25
Total	8.19	4.61	5.15	9.37	5.01	7.31	15.59	8.62	12.48	9.55	12.97
September	3.29	3.35	2.93	5.42	4.19	1.19	1.82	3.42	0.68	4.55	2.81
October	1.06	2.87	2.79	0.37	2.88	1.06	4.50	2.11	1.68	3.12	2.44
November	4.37	4.16	2.36	0.70	3.04	4.12	2.62	4.58	4.11	4.45	4.79
Total	8.72	10.38	8.08	6.49	10.11	6.37	8.94	10.11	6.47	12.12	10.04
Yearly total	34.77	29.72	28.06	31.21	28.19	29.65	40.70	33.69	37.56	45.43	40.20

Month.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	3.39	2.79	4.11	0.82	3.77	2.82	3.73	1.29	4.71	......
January	3.02	4.29	5.04	2.79	2.54	2.32	1.08	2.37	5.03	......
February	3.73	4.31	2.79	6.83	2.91	2.17	5.41	1.86	3.83	......
March	3.02	2.73	2.70	1.62	1.92	1.93	6.52	4.32	0.79	......
April	1.75	2.31	0.68	2.24	1.42	6.12	1.20	3.61	*b*2.84	......
May	5.06	2.25	5.79	4.99	3.94	1.64	1.53	3.81	*b*4.75	......
Total	19.97	18.68	21.11	19.29	16.50	17.00	19.47	17.26	21.95	......
June	3.81	2.44	4.96	1.26	3.02	2.83	3.01	6.21	*b*3.21	......
July	1.69	4.56	3.42	3.55	2.38	3.96	4.53	8.82	1.64	......
August	6.25	4.94	7.30	11.14	2.39	5.48	2.80	5.42	7.02	......
Total	11.75	11.94	15.68	15.95	7.79	12.27	10.34	20.45	11.87	......
September	4.12	1.12	2.73	3.35	3.13	2.14	4.81	1.19	3.42	......
October	4.25	2.06	1.86	1.36	4.72	0.98	3.65	1.52	5.28	......
November	1.56	2.66	2.93	1.04	2.87	4.81	5.55	10.02	3.59	......
Total	9.93	5.84	7.52	5.75	10.72	7.93	14.01	12.73	12.29	......
Yearly total	41.65	36.46	44.31	40.99	35.01	37.20	43.82	50.44	46.11	37.76

a Mean of sixteen years.

b Mean of—

Saratoga Springs	3.08	4.49	2.72
Lake George	3.35	5.02	2.96
	2)6.43	9.51	5.68
	3.21	4.75	2.84

Table No. 53.—*Record of precipitation at Gloversville for the water years 1892 to 1898, inclusive.*

Month.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	....	1.34	4.33	3.04	2.91	1.67	6.52	....
January	....	1.64	3.27	2.86	1.47	2.48	6.90	....
February	....	6.81	3.19	1.19	5.90	2.03	3.33	....
March	....	1.84	2.38	2.08	6.59	5.41	3.04	....
April	....	3.57	2.74	4.48	0.96	3.38	4.19	....
May	7.90	6.06	7.48	2.05	3.19	5.18	6.45	....
Total	....	21.26	23.39	15.70	21.02	20.15	30.43	....
June	4.91	1.95	4.95	3.19	3.79	6.72	5.14	....
July	3.27	2.69	3.06	3.41	4.95	9.80	4.73	....
August	9.23	5.80	1.64	5.15	2.01	3.46	6.90	....
Total	17.41	10.44	9.65	11.75	10.75	19.98	16.77	....
September	3.00	3.94	3.73	1.90	6.21	1.78	3.16	....
October	1.55	1.62	4.93	1.73	3.06	1.59	5.52	....
November	3.29	1.34	3.14	4.83	5.37	6.79	4.64	....
Total	7.84	6.90	11.80	8.46	14.64	10.16	13.32	....
Yearly total	....	38.60	44.84	35.91	46.41	50.29	60.52	46.10

Table No. 54.—*Record of precipitation at Gouverneur for certain water years, as indicated, from 1833 to 1875, inclusive.*

Month.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.
December	a1.48	1.66	0.95	0.47	......	1.63	0.72	1.48	0.60	2.42	4.30	0.26
January	1.66	1.17	5.80	......	......	1.45	3.30	0.16	2.60	1.10	1.68	2.60
February	4.19	1.19	2.22	......	......	0.24	0.55	0.49	0.12	2.67	2.50	0.45
March	0.77	1.93	3.25	......	......	0.50	0.60	1.82	2.46	1.09	0.00	1.68
April	1.32	1.85	8.25	......	......	0.50	0.96	2.48	0.90	0.26	0.70	0.40
May	3.81	2.52	3.95	......	......	2.03	3.14	1.89	1.69	0.77	0.14	1.99
Total	13.23	10.32	24.42	......	......	6.35	9.27	8.32	8.37	8.31	9.32	7.38
June	4.27	5.79	2.69	......	......	1.00	2.88	2.62	1.82	0.66	1.30	2.63
July	2.75	0.84	4.85	......	3.44	1.60	3.52	0.52	2.69	0.77	2.00	3.35
August	5.79	1.52	4.85	......	2.64	2.80	0.16	......	1.55	0.09	0.30	3.07
Total	12.81	8.15	12.39	......	......	5.40	6.56	......	6.06	1.52	3.90	9.05
September	2.41	2.54	2.44	......	3.97	1.84	1.34	......	3.14	2.69	1.00	1.45
October	3.38	3.73	4.57	......	2.87	5.00	0.60	......	1.03	2.74	4.75	5.39
November	1.79	2.67	2.82	......	3.31	2.34	1.10	......	2.35	1.80	1.10	1.15
Total	7.58	8.90	9.83	......	10.15	9.18	3.04	......	6.52	7.23	6.85	7.99
Yearly total	33.62	27.37	46.64	......	......	20.93	18.87	......	20.95	17.06	20.07	24.42

a Mean of—

Potsdam	0.80
Lowville	2.16
	2.96
Mean =	1.48

TABLE NO. 54.—*Record of precipitation at Gouverneur for certain water years, as indicated, from 1833 to 1875, inclusive*—Continued.

Month.	1845.	1846.	1847.	1848.	1849.	1854.	1855.	1856.	1861.	1862.	1863.	1864.
December	1.30	1.76	......	3.24	1.03	*a*1.04	2.21	2.33	*a*2.96	5.00	2.82	2.56
January	3.21	1.54	2.44	2.49	1.44	2.62	2.58	......	2.70	3.82	3.03	2.04
February	5.20	3.06	......	2.35	0.51	0.30	0.10	......	3.10	2.10	3.89	1.70
March	2.85	1.60	0.58	2.05	1.34	2.00	1.65	......	1.35	4.98	2.60	2.47
April	3.02	0.45	0.78	1.90	1.45	2.60	0.85	......	3.45	1.17	1.66	3.21
May	2.10	3.15	1.27	4.16	0.72	1.35	0.40	......	4.75	2.55	2.13	3.27
Total	17.68	11.56	......	16.19	6.49	9.91	7.79	......	18.31	19.62	16.13	15.25
June	4.23	2.00	8.17	3.44	1.28	3.50	6.60	......	3.75	1.96	1.28	0.52
July	0.69	1.87	......	3.89	0.66	0.10	3.05	......	9.00	2.10	2.84	0.74
August	0.10	......	......	1.81	0.81	1.85	1.30	......	2.75	3.06	1.75	2.65
Total	5.02	......	......	9.14	2.75	5.45	10.95	......	15.50	7.12	5.87	3.91
September	6.07	4.13	2.19	0.98	......	4.75	1.75	......	6.30	2.46	3.44	5.65
October	2.37	......	2.16	0.61	......	4.90	4.90	......	3.60	3.49	2.33	4.30
November	3.51	......	3.47	0.99	......	2.80	0.15	......	5.00	2.77	3.73	5.78
Total	11.95	......	7.82	2.58	......	12.45	6.80	......	14.90	8.72	9.50	15.73
Yearly total	34.65	......	......	27.91	......	27.81	25.54	......	48.71	35.46	31.50	34.89

Month.	1865.	1866.	1867.	1868.	1869.	1870.	1871.	1872.	1873.	1874.	1875.	Mean
December	4.29	2.50	3.76	0.96	1.77	2.68	3.34	3.29	2.25	2.30	1.56	......
January	1.48	1.55	1.21	2.00	1.78	4.25	1.84	1.23	4.17	4.93	2.14	......
February	1.57	2.97	2.62	1.53	5.15	2.73	1.47	1.47	1.21	2.57	1.87	......
March	2.83	2.61	1.49	1.86	2.50	2.79	4.46	1.63	5.30	3.41	......	......
April	3.13	2.46	4.42	1.65	1.18	0.96	1.41	0.57	2.76	2.88	......	......
May	1.51	3.06	6.92	4.33	3.82	1.01	1.76	2.44	1.68	0.79	......	......
Total	14.81	15.15	20.42	12.33	16.20	14.42	14.28	10.63	17.37	16.97	......	......
June	3.91	4.14	1.72	1.82	3.81	3.50	1.58	2.80	3.78	2.62	.....	......
July	1.85	2.45	2.52	1.91	3.13	2.37	3.33	2.66	4.18	3.84	......	......
August	0.99	5.96	1.98	1.25	1.74	1.87	2.84	2.16	2.21	1.39	......	......
Total	6.75	12.55	6.22	4.98	8.68	7.74	7.75	7.62	10.17	7.85	......	.....
September	2.36	6.02	2.76	3.58	4.04	2.70	1.48	2.59	2.42	2.37	......	......
October	3.32	2.61	3.09	1.95	5.66	3.64	1.63	4.80	5.03	3.87	......	......
November	2.33	3.94	1.81	5.13	2.76	1.71	1.73	3.20	2.74	2.55	......	......
Total	8.01	12.57	7.66	10.66	12.46	8.05	4.84	10.59	10.19	8.79	......	......
Yearly total	29.57	40.27	34.30	27.97	37.34	30.21	26.87	28.84	37.73	33.61	......	30.50

Yearly mean, 1833-1855, thirteen years, 26.64.
Yearly mean, 1861-1874, fourteen years, 34.09.

a Pierpont Manor record.

TABLE NO. 55.—*Record of precipitation at Granville for certain water years, as indicated, from 1835 to 1849, inclusive.*

Month.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.
December	a 1.98	1.17	3.90	2.18	2.55	1.98	1.30	1.98
January	2.99	2.32	....	1.33	1.79	2.10	1.98	0.64
February	1.08	3.52	....	0.59	1.35	1.60	0.26	1.07
March	1.20	0.65	....	0.39	1.66	1.71	2.30	2.48
April	3.36	2.57	....	0.64	2.08	2.05	4.70	3.29
May	2.84	3.69	....	4.33	2.96	3.65	2.68	2.80
Total	13.45	14.42	....	9.46	12.39	13.09	13.22	12.26
June	4.78	1.90	....	3.46	4.73	4.29	1.15	3.25
July	3.18	0.63	....	2.30	4.13	1.68	0.90	3.80
August	5.02	1.72	....	4.33	1.50	3.43	1.42	1.91
Total	12.98	4.25	....	10.09	10.36	9.40	3.47	8.96
September	1.53	1.30	....	2.48	2.30	2.50	2.54	3.53
October	1.79	3.63	....	2.89	1.45	3.79	0.70	1.81
November	1.96	2.45	....	3.36	2.01	2.18	1.25	3.70
Total	5.28	7.38	....	8.73	5.76	8.47	4.49	9.04
Yearly total	31.71	26.05	....	28.28	28.51	30.96	21.18	30.26

Month.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	Mean.
December	1.76	1.67	1.14	1.78	2.83	6.15	5.21	2.41
January	0.45	2.46	3.30	2.36	3.03	3.09	0.80	2.08
February	1.17	1.03	1.32	1.62	2.32	1.94	1.08	1.42
March	3.66	1.68	1.18	1.65	1.53	2.23	2.04	1.74
April	2.36	1.06	3.18	1.03	1.47	1.01	1.02	2.13
May	2.24	4.06	4.19	3.45	2.94	5.21	3.53	3.47
Total	11.64	11.96	14.31	11.89	14.12	19.63	13.68	13.25
June	1.86	2.08	4.23	3.27	3.36	4.36	2.21	3.21
July	4.94	2.65	3.13	3.59	6.27	12.52	1.01	3.63
August	2.91	2.10	3.42	0.63	4.22	3.57	5.44	2.97
Total	9.71	6.83	10.78	7.49	13.85	20.45	8.66	9.81
September	1.63	4.93	4.45	3.58	3.80	1.74	1.13	2.67
October	1.16	4.90	2.51	3.00	5.04	2.74	5.22	2.90
November	1.86	1.96	7.54	4.07	3.14	2.15	2.63	2.88
Total	4.65	11.79	14.50	10.65	11.98	6.63	8.98	8.45
Yearly total	26.00	30.58	39.59	30.03	39.95	46.71	31.32	31.51

a Cambridge record.

Table No. 56.—*Record of precipitation at Hamilton for certain water years, as indicated, from 1827 to 1850, inclusive.*

Month.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1839.
December	*a*4.16	5.52	0.37	2.50	5.78	1.90	3.47	1.93	3.24	*b*1.26	2.37	*c*0.84
January	2.33	1.53	3.60	1.60	2.25	3.09	2.20	2.75	......	4.57	......	2.99
February	3.48	3.25	3.05	1.00	3.59	4.65	5.84	1.59	......	1.33	......	0.80
March	3.00	1.68	1.95	5.51	0.52	1.25	3.14	2.59	......	1.35	......	1.09
April	1.93	1.75	4.50	1.35	4.18	1.89	0.52	1.17	......	1.95	......	1.19
May	1.11	2.91	1.65	2.84	1.49	1.85	5.16	2.65	......	4.85	......	4.17
Total	16.01	16.64	15.12	14.80	17.81	14.63	20.33	12.68	......	15.31	......	11.08
June	2.68	5.35	3.45	6.60	4.20	0.73	2.26	3.74	......	5.68	......	4.42
July	3.21	6.20	2.55	6.75	2.74	3.40	7.79	3.04	......	3.35	......	5.27
August	3.89	2.38	1.67	0.74	3.89	6.73	2.65	1.85	......	2.65	......	1.90
Total	9.78	13.93	7.67	14.09	10.83	10.86	12.70	8.63	......	11.68	......	11.59
September	6.75	3.53	3.56	2.15	2.85	2.83	5.50	4.08	......	6.14	......	2.51
October	7.77	1.14	1.58	2.29	3.71	2.18	2.96	4.29	......	4.37	......	1.28
November	1.77	4.09	2.75	6.10	2.11	3.24	3.25	1.51	......	1.44	......	2.28
Total	16.29	8.76	7.89	10.54	8.67	8.25	11.71	9.88	......	11.95	......	6.07
Yearly total	42.08	39.33	30.68	39.43	37.31	33.74	44.74	31.19	......	38.94	......	28.74

Month.	1840.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	Mean.
December	3.10	*c*2.80	2.47	1.33	1.23	1.38	2.87	3.27	4.99	2.37	......
January	......	1.68	1.56	1.57	2.94	1.60	1.79	1.48	1.18	......	......
February	......	3.23	2.30	1.10	4.25	3.24	3.04	1.26	0.65	......	......
March	......	3.55	3.30	1.27	2.69	2.37	1.59	2.77	1.32	......	......
April	......	2.49	2.30	1.51	2.63	1.30	1.37	1.25	1.47	......	......
May	......	2.04	1.65	4.39	2.34	3.91	2.33	4.25	3.23	......	......
Total	......	15.79	13.58	11.17	16.08	13.80	12.99	14.28	12.84	......	......
June	......	3.10	3.60	1.54	1.75	2.52	4.83	1.57	4.40	......	......
July	......	4.49	2.16	2.81	2.03	4.20	2.74	5.29	0.37	......	......
August	......	3.53	4.48	2.71	0.94	1.77	2.68	1.98	2.17	......	......
Total	......	11.12	10.24	7.06	4.72	8.49	10.25	8.84	6.94	......	......
September	......	5.95	4.08	2.80	3.26	3.63	3.15	1.98	1.48	......	......
October	......	2.77	2.76	3.61	2.68	1.17	3.30	1.73	6.52	......	......
November	......	1.88	3.35	1.10	2.72	2.52	1.62	1.95	2.02	......	......
Total	......	10.60	10.19	7.51	8.66	7.32	8.07	5.66	10.02	......	......
Yearly total	......	37.51	34.01	25.74	29.46	29.61	31.31	28.78	29.80	......	34.02

a **Mean of—**

Onondaga	**1.96**
Utica	**6.37**
	2)8.83
	4.16

b **Mean of—**

Bridgewater	**1.66**
Pompey	**0.97**
Utica	**1.16**
	3)3.79
	1.26

c **Mean of—**

Cazenovia	**1.14**	**4.32**
Pompey	**0.55**	**1.59**
Onondaga	**0.84**	**2.49**
	3)2.53	**8.40**
	0.84	**2.80**

TABLE No. 57.—*Record of precipitation at Hartwick for certain water years, as indicated, from 1826 to 1851, inclusive.*

Month.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1835.	1836.	1837.
December	a2.47	1.07	5.05	0.45	3.60	3.91	2.08	2.80	b2.71	0.70	b2.85
January	3.54	3.13	3.16	3.43	2.21	2.45	4.41	......	2.53	......	0.20
February	3.49	2.81	2.70	2.01	1.00	4.25	4.00	......	1.26	......	1.62
March	3.93	3.01	1.39	2.79	5.02	2.49	1.92	......	1.07	......	1.85
April	3.52	5.31	2.77	5.20	2.62	5.00	1.95	......	3.78	......	2.36
May	0.48	2.17	3.34	2.82	2.56	3.64	3.95	......	1.91	......	4.33
Total	17.43	17.50	18.41	16.70	17.01	21.81	18.80	......	13.26	......	13.21
June	9.11	3.18	3.67	4.54	7.08	5.05	1.60	......	4.58	......	3.51
July	3.69	5.34	2.73	4.61	5.10	4.04	4.29	......	4.33	......	2.80
August	0.76	6.08	3.56	2.50	0.55	4.98	4.92	......	4.15	......	2.94
Total	13.56	14.60	9.96	11.65	12.73	14.07	10.81	......	13.06	......	9.25
September	5.92	5.85	3.47	2.75	2.83	3.78	1.43	......	1.13	......	0.88
October	3.59	7.86	1.26	3.25	3.52	3.90	3.16	......	3.07	......	3.68
November	3.25	3.63	4.17	3.33	5.19	2.93	3.40	......	1.97	......	1.84
Total	12.76	17.34	8.90	9.33	11.54	10.61	7.99	......	6.17	......	6.40
Yearly total	43.75	49.44	37.27	37.68	41.28	46.49	37.60	......	32.49	......	28.86

Month.	1838.	1839.	1840.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	Mean.
December	2.35	b2.41	0.98	b1.42	1.59	3.28	b3.27	4.19	b2.37	2.54	......
January	......	2.29	......	2.92	2.70	......	2.26	......	1.45	......	......
February	......	0.80	......	1.95	1.32	......	0.74	......	1.58	......	......
March	......	0.90	......	3.40	3.01	......	2.25	......	3.25	......	......
April	......	2.71	......	2.79	1.15	......	1.40	......	2.78	......	......
May	......	2.43	......	3.57	6.64	......	5.78	......	3.19	......	......
Total	......	12.07	......	16.05	16.41	......	15.70	......	14.62	......	......
June	......	2.40	......	4.10	3.29	......	1.97	......	2.66	......	......
July	......	3.59	......	4.42	4.15	......	4.41	......	5.91	......	......
August	......	1.33	......	1.94	1.89	......	3.22	......	1.94	......	......
Total	......	7.32	......	10.46	9.33	......	9.60	......	10.51	......	......
September	......	3.04	......	4.68	2.19	......	2.06	......	3.23	......	......
October	......	0.75	......	5.82	2.95	......	2.73	......	4.05	......	......
November	......	2.16	......	4.57	3.82	......	1.63	......	2.91	......	......
Total	......	5.95	......	15.07	8.96	......	6.42	......	10.19	......	......
Yearly total	......	25.34	......	41.58	34.70	......	31.72	......	35.32	......	37.40

a Mean of fourteen years.

b Mean of—

Oxford	2.79	2.67	1.03	1.18	....	....
Cherry Valley	2.52	3.51	....	0.81	....	....
Hamilton	3.24	2.37	....	1.43	3.27	2.37
Johnstown	2.31	....	3.45	2.27	....	....
	4)10.86	3)8.55	2)4.48	4)5.69	3.27	2.37
	2.71	2.85	2.24	1.42		

Table No. 58.—*Record of precipitation at Houseville for the water years 1866 to 1870, inclusive.*

Month.	1866.	1867.	1868.	1869.	1870.	Mean.
December	....	4.01	3.25	3.97	3.68	....
January	....	1.53	2.57	3.99	6.49	....
February	....	3.66	1.61	4.25	2.87	....
March	....	2.11	3.31	4.46	3.60	....
April	....	5.78	2.74	2.69	1.39	....
May	....	6.82	4.61	3.59	*b* 1.43	....
Total	....	23.91	18.09	22.95	19.46	....
June	....	2.24	4.53	3.39	0.80	....
July	4.47	4.12	4.35	7.96	3.95	....
August	4.69	3.33	4.88	*a* 1.94	2.51	....
Total	....	9.69	13.76	13.29	7.26	....
September	7.92	2.48	5.35	6.12	4.08	....
October	3.23	3.80	4.18	6.97	4.99	....
November	8.10	3.62	4.95	4.92	*c* 1.65	....
Total	19.25	9.90	14.48	18.01	10.72	....
Yearly total	....	43.50	46.33	54.25	37.44	45.38

Gouveneur	*a* 1.87	*b* 1.76	*c* 1.73
Depauville	2.75	1.34	1.95
Pierpont Manor	3.16	1.18	1.27
	3)7.78	3)4.28	3)4.95
	1.94	1.43	1.65

Table No. 59.—*Record of precipitation at Hudson for certain water years, as indicated, from 1827 to 1856, inclusive.*

Month.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1842.	1843.	1844.
December	*a* 1.27	2.90	1.37	3.82	*b* 4.48	2.27	4.40	3.10	4.18	1.19	4.00	4.47	0.62
January	2.47	2.40	3.73	......	4.50	4.10	2.95	1.45	4.60	......	0.92	2.17	2.60
February	2.26	5.30	3.30	......	3.50	3.27	2.00	0.40	0.65	......	2.89	4.80	1.02
March	1.28	2.90	2.10	......	1.55	4.15	2.80	1.04	2.45	......	1.81	5.42	2.94
April	4.55	2.24	3.80	......	4.25	4.30	0.90	5.85	4.50	......	2.65	2.31	0.81
May	3.31	3.25	1.69	......	2.95	1.20	5.90	4.86	2.29	......	1.62	1.51	3.82
Total	15.14	18.99	15.99	......	21.23	19.29	18.95	16.70	18.67	......	13.89	20.68	11.81
June	2.60	7.87	3.15	......	3.60	2.36	3.20	4.10	5.79	......	3.45	4.58	3.93
July	3.67	3.21	4.56	......	3.78	6.34	5.00	3.20	4.00	......	4.07	2.81	5.89
August	4.20	0.85	1.41	......	5.61	3.60	4.12	0.95	3.56	......	4.77	6.15	1.71
Total	10.47	11.93	9.12	......	12.99	12.30	12.32	8.25	13.44	......	12.29	13.54	11.53
September	4.75	7.89	0.66	......	4.30	4.30	2.75	0.95	1.88	......	3.59	1.57	1.52
October	4.30	1.25	2.76	......	6.09	4.15	8.40	2.35	1.65	......	2.85	5.91	3.41
November	3.58	5.72	2.49	......	2.25	3.40	1.40	1.16	1.65	......	2.48	1.94	0.86
Total	12.63	14.86	5.91	......	12.64	11.85	12.55	4.46	5.18	......	8.92	9.42	5.79
Yearly total	38.24	45.78	31.02	......	46.86	43.44	43.82	29.41	37.29	......	35.10	43.64	29.13

a Albany record.
b Mean of—

Kinderhook	4.57	3.82
Red Hook	4.38	4.17
	2)8.95	7.99
	4.48	4.00

TABLE NO 59.—*Record of precipitation at Hudson for certain water years, as indicated, from 1827 to 1856, inclusive*—Continued.

Month.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	Mean
December	3.97	2.89	2.34	4.76	3.88	1.01	......	1.15	3.32	13.00	*a*2.16	8.77	......
January	3.00	1.95	3.77	1.59	0.73	......	......	1.74	3.04	......	6.56	......	......
February	1.30	0.82	3.67	1.48	0.62	......	......	2.06	3.18	......	7.97	......	......
March	2.32	4.04	4.53	1.76	3.25	......	......	2.68	1.74	......	5.95	......	......
April	1.54	0.45	0.92	0.42	1.18	......	......	3.52	3.91	......	5.18	......	......
May	2.10	3.77	1.98	5.02	4.74	......	......	1.59	7.49	......	5.07	......	......
Total	14.23	13.93	17.21	15.03	14.40	......	......	12.74	22.68	......	32.89	......	......
June	1.46	1.41	4.27	5.49	1.57	......	......	1.98	2.16	......	9.16	......	......
July	3.12	3.74	2.38	1.50	1.23	......	......	5.11	3.44	......	6.41	......	......
August	1.36	1.49	2.88	2.40	2.62	......	......	5.09	5.72	......	2.64	......	......
Total	5.94	6.64	9.53	9.30	5.42	......	......	12.18	11.32	......	18.21	......	......
September	2.37	0.73	4.33	2.08	0.08	......	2.09	1.88	7.51	......	4.60	......	......
October	1.73	2.00	3.72	4.74	8.36	......	2.94	2.75	2.62	......	7.93	......	......
November	3.69	2.98	0.98	2.78	4.15	......	3.86	4.42	1.82	......	6.00	......	......
Total	7.79	5.71	9.03	9.60	12.59	......	8.89	9.05	11.95	......	18.53	......	......
Yearly total	27.96	26.27	35.77	34.02	32.41	......	......	33.97	45.95	......	69.63	......	38.41

a Mean of—

Albany	1.84
Spencertown	2.47
	2)4.31
	2.16

TABLE NO. 60.—*Record of precipitation at Humphrey for the water years 1889 to 1898, inclusive.*

Month.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	*a*3.21	4.98	1.91	4.38	1.95	5.74	1.89	2.82	1.62	3.59	......
January	3.16	5.02	1.82	3.39	2.62	4.41	3.25	2.43	3.06	4.57	......
February	1.03	3.91	4.55	3.45	5.52	1.83	1.67	4.83	2.56	2.47	......
March	2.34	3.34	2.36	3.45	2.63	2.27	1.54	3.33	2.19	3.87	......
April	4.26	4.95	2.17	1.48	5.61	4.53	1.31	1.31	1.39	3.22	......
May	6.27	9.11	1.45	7.46	5.42	9.50	1.46	3.35	3.84	3.62	......
Total	20.27	31.31	14.26	23.61	23.95	28.28	11.12	18.07	14.66	21.34	......
June	8.85	3.76	5.95	6.34	4.54	4.43	2.83	3.63	3.71	6.87	......
July	3.16	3.43	7.22	4.88	3.66	2.45	3.52	7.50	7.77	2.59	......
August	1.63	5.11	6.63	4.45	5.82	2.50	3.71	4.49	2.68	9.21	......
Total	13.64	12.30	19.80	15.67	14.02	9.38	10.06	15.62	14.16	18.67	......
September	3.12	9.00	2.04	2.55	3.83	8.84	1.90	5.05	1.25	3.22	......
October	2.40	5.94	2.42	3.65	4.27	3.37	2.22	3.00	0.60	6.04	......
November	4.51	3.81	4.09	4.02	2.56	1.64	4.47	2.93	4.83	3.15	......
Total	10.03	18.75	8.55	10.22	10.66	13.85	8.59	10.98	6.68	12.41	......
Yearly total	43.94	62.36	42.61	49.50	48.63	51.51	29.77	44.67	35.50	52.42	46.09

a Mean of all Decembers.

Table No. 61.—*Record of precipitation at Ithaca for certain water years, as indicated, from 1828 to 1898, inclusive.*

Month.	1828.	1829.	1830.	1831.	1833.	1834.	1837.	1838.	1839.	1840.	1842.
December	*a*2.66	0.50	*b*1.90	1.47	*c*2.50	3.25	*d*2.67	1.20	0.62	1.72	*b*4.99
January	1.22	......	0.60	......	2.30	......	0.47	1.24	3.76	......	2.77
February	1.05	......	0.47	......	2.86	......	1.57	0.93	1.36	......	3.16
March	0.38	......	2.82	......	1.25	......	2.19	1.66	2.08	......	3.79
April	1.20	......	2.06	......	1.78	......	0.93	2.01	1.90	......	2.91
May	1.30	......	5.53	......	0.90	......	6.20	6.61	4.07	......	2.12
Total	7.81	......	13.38	......	11.59	......	14.03	13.65	13.79	......	19.74
June	3.41	......	5.08	......	1.47	......	3.61	5.28	4.34	......	5.10
July	4.37	......	3.52	......	3.70	......	2.89	3.76	2.69	......	4.28
August	1.20	......	1.92	......	2.78	......	3.39	2.86	1.31	......	2.67
Total	8.98	......	10.52	......	7.95	......	9.89	11.90	8.34	......	12.05
September	5.49	......	3.67	......	1.60	......	1.46	2.17	1.88	......	5.15
October	1.20	......	1.49	......	2.57	......	3.42	3.57	0.28	......	2.37
November	3.13	......	6.98	......	2.18	......	0.91	3.11	1.83	......	2.46
Total	9.82	......	12.14	......	6.35	......	5.79	8.85	3.99	......	9.98
Yearly total	26.61	......	36.04	......	25.89	......	29.71	34.40	26.12	......	41.77

Month	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.
December	2.97	1.82	1.03	0.82	1.46	3.39	5.25	......	4.46	1.20	......
January	2.37	1.86	2.13	1.87	1.97	0.89	......	......	2.72	1.90	2.00
February	1.31	0.45	2.65	2.54	2.41	0.54	......	......	2.88	0.25	......
March	2.11	2.47	2.91	2.51	1.94	1.80	......	......	2.03	4.76	......
April	3.27	1.69	3.42	0.85	0.85	1.00	......	......	3.04	3.72	4.30
May	1.05	3.85	2.16	1.08	2.01	4.93	......	......	3.02	3.85	......
Total	13.08	12.14	14.30	9.67	10.64	12.55	......	......	18.15	15.68	......
June	3.90	1.30	2.07	3.84	2.71	2.46	......	......	4.34	2.00	4.85
July	2.80	5.24	2.78	2.43	0.86	4.25	......	......	3.46	3.67	2.85
August	3.80	2.23	2.30	3.47	2.58	3.87	......	......	1.78	2.52	6.20
Total	10.50	8.77	7.15	9.74	6.15	10.58	......	......	9.58	8.19	13.90
September	6.90	1.16	3.46	1.84	6.31	2.05	......	2.33	2.90	2.03	......
October	3.75	3.07	3.85	3.07	3.68	0.96	......	4.60	1.78	2.87	......
November	2.06	1.84	3.35	5.75	2.68	0.87	......	2.00	1.91	2.01	......
Total	12.71	6.07	10.66	10.66	12.67	3.88	......	8.93	6.59	6.91	......
Yearly total	36.29	26.98	32.11	30.07	29.46	27.01	......	......	34.32	30.78	......

a Ledyard record.

b Mean of—

Oxford	2.52	4.27
Prattsburg	1.27	5.70
	2)3.79	9.97
	1.90	4.99

c Mean of—

Oxford	3.87
Ledyard	1.12
	2)4.99
	2.50

d Oxford record.

TABLE NO. 61.—*Record of precipitation at Ithaca for certain water years, as indicated, from 1828 to 1898, inclusive*—Continued.

Month.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	*a*2.83	2.46	3.47	3.85	0.85	2.03	2.39	4.07	1.00	2.56	......
January	3.19	2.68	2.99	3.78	1.32	2.78	2.18	1.46	1.50	2.21	......
February	1.30	2.17	3.17	1.33	2.93	2.31	0.92	4.61	0.91	1.50	......
March	1.70	3.82	3.30	2.88	2.49	1.28	1.26	4.75	3.04	1.63	......
April	3.43	3.34	2.45	1.25	3.79	4.84	1.47	1.02	2.47	3.58	......
May	2.63	6.60	0.61	6.46	6.04	7.34	3.60	2.64	3.84	4.55	......
Total	15.08	21.07	15.99	19.55	17.42	20.58	11.82	18.55	12.76	16.12	......
June	6.74	4.94	4.56	5.20	2.21	3.40	3.37	4.36	3.54	3.01	......
July	6.73	1.24	4.25	4.23	5.13	3.17	1.93	3.69	3.25	4.17	......
August	3.32	4.92	3.24	6.91	3.86	0.59	4.12	2.43	2.74	4.42	......
Total	16.79	11.10	12.05	16.34	11.20	7.16	9.45	10.48	9.53	11.60	......
September	2.57	6.62	2.13	1.88	4.38	5.17	2.03	3.84	4.72	3.15	......
October	3.62	4.66	5.25	1.52	2.15	4.94	0.99	4.37	0.88	5.87	......
November	3.35	1.93	2.25	3.50	1.25	1.94	2.69	2.00	4.22	3.15	......
Total	9.54	13.21	9.63	6.90	7.78	12.05	5.71	10.21	9.82	12.17	......
Yearly total	41.41	45.38	37.67	42.79	36.40	39.79	26.98	39.24	32.11	39.89	33.97

a Mean of—

Cooperstown	3.30
Geneva	1.24
Auburn	3.94
	3)8.48
	2.83

TABLE NO. 62.—*Record of precipitation at Johnstown for certain water years, as indicated, from 1828 to 1845, inclusive.*

Month.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.
December	*a*3.60	0.64	2.20	*a*4.38	1.10	3.51	*a*3.70	2.31	0.50
January	2.99	4.11	....	3.60	4.50	....	2.10	3.76	1.90
February	2.57	2.51	....	3.61	3.86	....	1.71	1.98	2.80
March	3.19	2.15	....	3.05	0.80	....	2.62	3.42	3.24
April	2.88	4.49	....	3.25	0.97	....	3.39	4.42	2.87
May	4.82	2.63	....	2.23	4.79	....	3.67	1.95	1.99
Total	20.05	16.53	....	20.12	16.02	....	17.19	17.84	13.30
June	4.39	3.84	....	5.07	1.84	....	3.52	8.04	3.84
July	5.18	3.63	....	5.11	4.85	....	3.87	4.71	3.75
August	2.95	1.61	....	2.59	1.94	....	1.54	5.95	1.50
Total	12.52	9.08	....	12.77	8.63	....	8.93	18.70	9.09
September	4.12	3.49	....	2.70	1.05	....	3.85	0.71	2.74
October	2.00	3.10	....	3.82	1.29	....	4.86	2.11	3.84
November	4.66	2.83	....	0.75	3.33	....	1.70	3.46	2.03
Total	10.78	9.42	....	7.27	5.67	....	10.41	6.28	8.61
Yearly total	43.35	35.03	....	40.16	30.32	....	36.53	42.82	31.00

a Cherry Valley record.

TABLE NO. 62.—*Record of precipitation at Johnstown for certain water years, as indicated, from 1828 to 1845, inclusive*—Continued.

Month.	1837.	1838.	1839.	1841.	1842.	1843.	1844.	1845.	Mean.
December	6.90	4.95	3.45	*a*1.04	5.18	2.79	2.25	2.27	2.98
January	4.64	4.88	....	3.51	1.72	1.16	3.95	3.45	3.30
February	3.74	3.60	....	0.87	3.71	1.25	3.90	4.00	2.86
March	6.73	5.47	....	3.90	3.49	3.38	6.00	3.44	3.63
April	4.01	2.02	....	2.34	3.13	2.35	1.97	2.90	2.93
May	8.56	4.53	....	2.89	1.91	1.95	4.03	2.29	3.45
Total	34.58	25.45	....	14.55	19.14	12.88	22.10	18.35	19.15
June	2.76	5.45	....	3.65	6.29	3.44	3.72	2.98	4.20
July	3.98	2.26	....	3.18	5.23	2.12	4.52	3.70	4.01
August	2.40	7.48	....	2.77	4.39	3.17	4.66	1.07	3.14
Total	9.14	15.19	....	9.60	15.91	8.73	12.90	7.75	11.35
September	2.44	1.61	....	4.48	4.10	2.96	4.16	1.83	2.87
October	3.45	3.20	....	1.14	2.95	4.74	5.82	3.64	3.29
November	2.81	5.68	....	3.32	4.26	2.39	4.77	4.68	3.33
Total	8.70	10.49	....	8.94	11.31	10.09	14.75	10.15	9.49
Yearly total	52.42	51.13	....	33.09	46.36	31.70	49.75	36.25	39.99

a Fairfield record.

TABLE NO. 63.—*Record of precipitation at Keene Valley for certain water years, as indicated, from 1879 to 1898, inclusive.*

Month.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
December	6.74	2.97	0.77	3.20	1.74	1.14	3.03	2.32	1.51	2.76
January	1.35	3.33	2.08	1.73	1.55	2.88	4.29	4.03	3.05	2.30
February	2.44	2.69	2.20	1.99	2.60	3.13	3.22	1.38	2.92	1.52
March	2.49	1.75	4.10	4.31	1.83	3.18	1.36	1.70	2.38	3.23
April	2.24	2.18	1.01	0.94	1.57	1.47	2.75	4.33	2.00	1.89
May	0.82	2.74	2.99	2.46	6.03	3.01	1.44	2.33	0.81	2.92
Total	16.08	15.66	13.15	14.63	15.32	14.81	16.09	16.09	12.67	14.62
June	2.72	1.65	2.59	4.05	2.73	1.34	1.23	1.85	3.48	3.42
July	2.89	3.05	2.25	1.88	3.41	2.15	3.56	3.22	5.76	2.46
August	1.99	2.68	2.86	2.62	1.32	3.71	8.05	4.15	1.79	4.33
Total	7.60	7.38	7.70	8.55	7.46	7.20	12.84	9.22	11.03	10.21
September	2.93	3.65	3.21	3.74	2.54	1.81	2.88	3.47	0.53	4.49
October	0.88	3.77	2.42	0.73	2.39	2.32	5.34	2.37	1.20	2.92
November	4.66	2.86	1.72	1.43	1.99	2.44	4.19	6.01	3.27	5.06
Total	8.47	10.28	7.35	5.90	6.92	6.57	12.41	11.85	5.00	12.47
Yearly total	32.15	33.32	28.20	29.08	29.70	28.58	41.34	37.16	28.70	37.30

Month.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1898.	Mean.
December	2.72	4.50	2.58	3.97	0.61	3.92	2.20	*a*1.90	....
January	5.43	4.03	4.63	5.02	1.85	2.33	1.12	7.20	....
February	1.09	3.50	3.01	1.37	2.48	1.61	0.61	2.80	....
March	0.68	2.84	3.59	1.41	0.95	1.40	0.96	2.30	....
April	2.63	2.61	2.11	1.80	2.37	1.22	2.34	2.85	....
May	3.33	4.41	1.80	4.33	5.37	4.44	2.60	2.20	....
Total	15.88	21.89	17.72	17.90	13.63	14.92	9.83	19.25	....
June	5.77	3.13	3.39	3.59	1.33	2.72	4.21	2.50	....
July	7.92	1.84	2.75	8.48	4.78	1.86	3.17	4.04	....
August	1.44	7.71	2.96	5.87	9.92	2.10	8.00	4.25	....
Total	15.13	12.68	9.10	17.94	16.03	6.68	15.38	10.79	....
September	3.04	4.74	1.38	2.71	2.29	3.79	3.75	3.56	....
October	2.60	3.42	2.29	1.77	2.21	4.22	1.43	3.86	....
November	3.78	2.88	4.36	4.10	1.94	4.05	5.79	2.53	....
Total	9.42	11.04	8.03	8.58	6.44	12.06	10.77	9.95	....
Yearly total	40.43	45.61	34.85	44.42	36.10	33.66	35.18	39.99	35.98

a Lake Placid record.

Table No. 64.—*Record of precipitation at Kinderhook for the water years from 1830 to 1847, inclusive.*

Mon	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.
December	*a*3.82	4.57	0.70	2.69	3.63	2.02	1.24	5.24	2.10	0.21
January	1.11	2.12	4.22	1.65	1.12	3.73	2.33	1.10	1.33	1.63
February	0.98	2.57	3.08	2.06	0.53	1.31	2.80	0.81	1.34	0.32
March	4.46	2.55	3.76	2.01	0.82	2.65	1.81	4.24	1.40	0.60
April	2.59	5.58	4.07	1.11	3.32	3.74	2.32	2.47	1.81	4.74
May	4.08	2.95	3.95	4.78	4.60	1.73	1.72	6.17	3.39	5.08
Total	17.04	20.34	19.78	14.30	14.02	15.18	12.22	20.03	11.37	12.58
June	7.32	5.62	4.04	3.23	2.53	9.70	4.77	5.65	5.48	3.00
July	2.34	4.50	10.19	4.71	3.72	4.03	4.10	2.62	4.02	6.57
August	0.55	6.04	5.91	4.03	0.78	4.50	2.83	2.08	4.17	1.69
Total	10.21	16.16	20.14	11.97	7.03	18.23	11.70	10.35	13.67	11.26
September	2.11	3.94	3.94	3.79	1.41	1.03	1.75	0.99	4.78	1.85
October	2.59	3.74	3.68	7.76	4.03	1.38	4.52	2.04	3.65	1.05
November	4.22	2.51	3.93	1.10	1.07	1.91	1.75	0.85	2.97	3.30
Total	8.92	10.19	11.55	12.65	6.51	4.32	8.02	3.88	11.40	6.20
Yearly total	36.17	46.69	51.47	38.92	27.56	37.73	31.94	34.26	36.44	30.04

Month	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	Mean.
December	4.32	3.13	3.82	3.08	1.86	3.65	2.52	2.06	....
January	1.75	4.81	1.05	1.67	2.16	3.03	2.72	....	....
February	1.79	0.39	2.35	2.03	0.99	1.83	0.90	....	....
March	1.97	1.33	2.08	3.60	3.35	2.79	2.79	....	....
April	2.26	3.83	4.79	3.84	0.86	2.37	0.81	....	....
May	1.36	1.86	1.10	2.15	5.84	3.18	3.98	....	....
Total	13.45	15.35	15.19	16.37	15.06	16.85	13.72	....	....
June	2.78	2.93	3.72	6.58	4.18	2.15	2.67	....	....
July	3.04	2.11	5.04	3.67	5.68	2.77	4.98	....	....
August	4.20	3.86	4.90	3.70	2.69	2.55	2.35	....	....
Total	10.02	8.90	13.66	13.95	12.55	7.47	10.00	....	....
September	4.43	3.29	6.16	2.13	2.45	3.47	0.79	....	....
October	3.51	1.29	3.95	5.05	3.83	3.01	0.26	....	....
November	3.19	3.12	2.75	2.22	2.01	4.80	4.08	....	....
Total	11.13	7.70	12.86	9.40	8.29	11.28	5.13	....	....
Yearly total	34.60	31.95	41.71	39.72	35.90	35.60	28.85	....	35.44

a Hudson record.

Table No. 65.—*Record of precipitation at Kings Station for the water years 1891 to 1898, inclusive.*

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	a 2.85	4.96	1.45	4.52	3.06	4.12	1.17	6.27	....
January	a 3.95	5.41	2.90	3.06	2.16	1.15	2.20	5.25	....
February	a 5.61	2.30	6.85	3.15	1.20	6.20	1.75	5.53	....
March	3.15	2.25	2.65	2.17	2.01	6.40	4.95	1.74	....
April	1.90	0.84	3.18	1.87	6.52	0.70	3.68	3.41	....
May	2.57	6.21	6.06	5.26	2.26	3.47	6.35	5.12	....
Total	20.03	21.97	23.09	20.03	17.21	22.04	20.10	27.32	....
June	2.47	4.49	1.52	5.11	3.40	2.21	6.63	3.24	....
July	4.04	4.31	5.11	3.63	3.65	4.30	8.83	2.55	....
August	3.93	6.66	11.25	3.14	3.86	2.19	4.70	9.64	....
Total	10.44	15.46	17.88	11.88	10.91	8.70	20.16	15.43	....
September	1.68	2.39	3.65	2.82	2.27	6.79	1.65	3.22	....
October	2.60	1.30	1.97	4.72	1.46	4.25	1.45	4.82	....
November	2.98	3.12	1.25	2.74	3.23	6.17	8.15	4.60	....
Total	7.26	6.81	6.87	10.28	6.96	17.21	11.25	12.64	....
Yearly total	37.73	44.24	47.84	42.19	35.08	47.95	51.51	55.39	45.24

a Galway record.

Table No. 66.—*Record of precipitation at Kingston for certain water years, as indicated, from 1829 to 1850, inclusive.*

Month.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.
December	a 0.33	2.00	5.06	4.35	1.92	3.20	3.56	2.15	5.30	2.40	1.00
January	4.53	1.93	3.66	5.26	4.92	2.85	3.94	3.15	1.15	2.08	2.45
February	3.06	1.07	4.38	4.15	3.19	1.41	1.20	1.95	0.80	1.50	1.00
March	3.60	3.76	3.62	2.86	2.82	2.92	2.33	1.54	5.75	2.28	1.38
April	4.98	3.33	4.48	2.50	2.57	2.70	5.98	1.91	1.40	1.57	2.55
May	2.44	5.16	3.16	2.36	5.03	3.48	1.70	2.98	6.68	6.25	4.71
Total	18.94	17.25	24.36	21.48	20.45	16.56	18.71	13.68	21.08	16.08	13.09
June	2.89	4.32	6.87	2.85	4.40	6.67	4.21	4.65	5.40	4.90	2.78
July	5.82	3.45	4.13	4.09	4.94	5.02	4.65	5.15	3.85	1.47	5.62
August	1.66	0.75	1.23	4.94	2.30	1.21	2.79	1.43	2.30	5.60	2.35
Total	10.37	8.52	12.23	11.88	11.64	12.90	11.65	11.23	11.55	11.97	10.75
September	2.12	1.60	2.30	0.79	2.47	2.39	1.28	2.76	1.57	4.80	2.80
October	3.32	2.72	4.37	3.15	4.50	2.06	1.41	3.17	1.95	2.18	0.65
November	2.57	7.00	2.80	3.38	3.70	1.58	2.30	3.13	0.78	3.61	3.10
Total	8.01	11.32	9.47	7.32	10.67	6.03	4.99	9.06	4.30	10.59	6.55
Yearly total	37.32	37.09	46.06	40.08	42.76	35.49	35.35	33.97	36.93	38.64	30.39

a Mean of—

Albany	0.24
Newburg	0.42
	2)0.66
	0.33

TABLE NO. 66.—*Record of precipitation at Kingston for certain water years, as indicated, from 1829 to 1850, inclusive*—Continued.

Month.	1840.	1841.	1842.	1843.	1845.	1846.	1847.	1848.	1849.	1850.	Mean.
December	4.03	2.92	2.93	4.44	*a*3.92	2.65	3.10	4.90	4.72	2.77	......
January	1.95	4.73	3.24	......	4.30	2.95	3.60	2.70	2.65	......	......
February	1.52	0.85	2.30	......	3.70	1.00	4.40	2.50	1.55	......	......
March	3.03	2.05	2.15	......	3.80	4.80	3.20	2.60	2.08	......	......
April	3.25	4.40	0.70	......	1.70	0.60	1.10	0.20	2.15	......	......
May	2.20	1.35	0.30	......	2.25	4.80	2.60	8.90	4.98	......	......
Total	15.98	16.40	11.62	......	19.67	16.80	18.00	21.80	18.13	......	......
June	2.70	4.10	2.60	......	1.80	2.50	4.60	3.63	1.21	......	......
July	1.82	4.58	6.87	......	3.70	4.30	3.00	4.80	0.60	......	......
August	2.90	4.17	5.80	......	1.10	3.50	1.70	0.65	4.70	......	......
Total	7.42	12.85	15.27	......	6.60	10.30	9.30	9.08	6.51	......	......
September	2.15	1.41	1.53	......	2.55	0.50	6.20	2.85	1.50	......	......
October	5.65	2.11	0.42	......	3.75	2.00	2.70	5.00	8.62	......	......
November	2.66	4.17	7.55	......	2.25	5.30	2.20	2.40	5.27	......	......
Total	10.46	7.69	9.50	......	8.55	7.80	11.10	10.25	14.79	......	......
Yearly total	33.86	36.84	36.39	......	34.82	34.90	38.40	41.13	39.43	......	37.42

a Mean of—

Poughkeepsie	3.86
Hudson	3.97
	2)7.83
	3.92

TABLE NO. 67.—*Record of precipitation at Ledyard for certain water years, as indicated from 1827 to 1851, inclusive.*

Month.	1827.	1828.	1830.	1831.	1832.	1833.	1834.	1835.	1844.	1845.	1850.	1851.	Mean
December	*a*1.26	2.66	*b*1.31	2.90	1.42	1.12	*b*2.76	1.44	*b*2.30	0.50	*c*3.41	4.80	......
January	3.54	......	1.08	4.42	1.61	......	1.08	......	0.75	......	1.07	......	......
February	2.12	......	0.63	1.34	2.43	......	1.01	......	0.25	......	3.45	......	......
March	2.85	......	3.20	1.24	1.01	......	2.00	......	0.70	......	0.70	......	......
April	2.51	......	2.10	3.33	1.93	......	2.34	......	1.42	......	1.01	......	......
May	2.13	......	4.82	2.34	2.65	......	2.34	......	5.15	......	6.70	......	......
Total	14.42	......	13.14	15.57	11.05	......	11.62	......	10.57	......	16.34	......	......
June	5.25	......	6.47	4.78	0.88	......	2.90	......	2.60	......	4.00	......	......
July	2.29	......	4.01	5.13	4.77	......	1.14	......	5.35	......	4.50	......	......
August	3.59	......	1.68	4.53	4.44	......	3.53	......	3.20	......	2.60	......	......
Total	11.13	......	12.16	14.44	10.00	......	7.57	......	10.55	......	11.10	......	......
September	2.37	......	3.48	2.94	3.58	......	2.68	......	1.80	......	4.94	......	......
October	4.73	......	1.09	3.22	1.95	......	1.98	......	4.95	......	4.51	......	......
November	1.54	......	5.62	1.41	2.69	......	2.64	......	0.65	......	3.92	......	......
Total	8.64	......	10.19	7.57	8.22	......	7.30	......	7.40	......	13.37	......	......
Yearly total	34.19	......	35.49	37.58	29.36	......	26.49	......	28.52	......	40.81	......	33.21

a Onondaga Hollow record.

b Mean of—

Ithaca	....	3.25	1.82
Auburn	0.66	2.25	4.22
Prattsburgh	1.27	....	1.35
Canandaigua	2.17	3.86	....
Onondaga	1.14	1.60	1.83
	4)5.24	11.05	9.22
	1.31	2.76	2.30

c Auburn record, 3.41.

TABLE NO. 68.—*Record of precipitation at Liberty for certain water years, as indicated, from 1850 to 1863, inclusive.*

Month.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.
December	....	4.23	3.88	5.26	1.32	5.09	5.34	4.52
January	....	0.98	2.29	2.61	3.94	8.64	1.45	3.60
February	....	7.69	3.75	5.01	5.43	1.57	1.22	2.24
March	....	3.15	6.71	3.91	1.85	0.78	1.87	3.38
April	....	10.91	4.05	4.73	6.70	3.02	2.40	8.76
May	....	3.67	3.10	5.62	5.55	2.82	4.48	7.17
Total	....	30.63	23.78	27.14	24.79	16.92	16.76	29.67
June	....	4.88	4.65	6.69	2.37	7.44	3.63	5.55
July	....	2.68	2.79	5.46	2.42	8.83	1.50	7.10
August	....	2.22	4.86	4.91	0.92	2.02	6.89	4.34
Total	....	9.78	12.30	17.06	5.71	18.29	12.02	16.99
September	....	3.72	1.85	5.04	3.20	1.42	1.92	2.94
October	2.82	2.68	3.08	5.59	3.63	4.62	9.10	3.76
November	2.57	3.64	5.43	4.36	9.02	4.62	2.89	2.30
Total	....	10.04	10.36	14.99	15.85	10.66	13.91	9.00
Yearly total	....	50.45	46.44	59.19	46.35	45.87	42.69	55.66

Month.	1858.	1859.	1860.	1861.	1862.	1863.	Mean.
December	4.32	1.88	6.35	6.73	....	3.20	....
January	2.89	2.96	1.86	5.45	1.75	1.50	....
February	2.65	2.53	2.97	2.18	....	0.50	....
March	1.39	5.41	1.55	2.67	....	0.74	....
April	2.29	3.95	1.41	7.05	0.16	....	....
May	5.29	5.18	3.96	2.82	1.70	....	....
Total	18.83	21.91	18.10	26.90	....	....	....
June	4.44	7.03	3.57	2.96	9.12	....	....
July	7.06	3.70	7.34	3.85	5.13	....	....
August	3.88	6.17	6.68	[a]4.00	1.15	....	....
Total	15.38	16.90	17.59	10.81	15.40	....	....
September	1.80	6.52	3.65	1.53	3.58	....	....
October	2.60	1.04	1.07	3.39	4.70	....	....
November	3.70	3.69	3.52	1.66	1.60	....	....
Total	8.10	11.25	8.84	6.58	9.88	....	....
Yearly total	42.31	50.06	44.53	44.29	....	....	47.98

[a] Mean of eleven years.

Table No. 69.—*Record of precipitation at Lowville for certain water years, as indicated, from 1827 to 1898, inclusive.*

Month.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1839.
December	a 1.96	2.90	2.70	2.35	4.82	2.11	2.16	2.88	0.90	2.50	b 1.35
January	3.38	2.65	2.01	1.99	2.48	2.05	2.10	....	3.02	....	3.29
February	1.91	3.55	3.10	1.75	5.71	4.24	1.75	....	2.40	....	1.18
March	0.30	1.50	1.13	4.53	1.35	1.45	1.30	....	1.35	....	1.97
April	1.88	1.44	2.60	0.35	3.38	1.00	1.45	....	2.61	....	1.19
May	1.02	2.67	1.83	2.10	2.75	3.15	6.40	....	1.64	....	3.76
Total	10.45	14.71	13.37	13.07	20.49	14.00	15.16	....	11.92	....	12.69
June	6.14	2.45	3.44	5.32	2.10	1.60	3.90	....	6.75	....	3.47
July	2.84	7.53	3.05	2.78	5.94	0.70	3.20	....	4.51	....	5.20
August	4.11	2.63	1.91	1.98	4.06	4.45	2.87	....	5.12	....	1.99
Total	13.09	12.61	8.40	10.08	12.10	6.75	9.97	....	16.38	....	10.66
September	2.18	3.25	1.36	2.77	3.25	2.52	2.98	....	1.48	....	2.82
October	4.80	2.51	1.67	3.05	3.48	3.05	4.50	....	5.49	....	0.46
November	1.40	2.60	3.82	5.24	2.18	2.75	1.77	....	2.25	....	2.30
Total	8.38	8.36	6.85	11.06	8.91	8.32	9.23	....	9.22	....	5.58
Yearly total	31.92	35.68	28.62	34.19	41.50	20.07	34.36	....	37.52	....	28.93

Month.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	18 years' mean.	1850.
December	0.82	3.72	2.37	1.37	1.05	1.01	0.90	0.59	8.01	2.00	....
January	4.36	3.15	0.55	1.16	2.70	2.95	1.05	1.96	1.38	2.35	....
February	2.36	0.29	5.67	1.00	1.06	1.73	1.86	3.35	0.80	2.43	....
March	3.21	3.20	2.36	0.70	1.88	1.94	1.25	1.96	0.68	1.78	....
April	4.57	1.65	2.39	1.42	1.26	1.71	0.99	3.76	0.68	1.91	....
May	3.73	1.02	1.72	1.31	3.58	3.56	3.71	1.41	4.83	2.79	....
Total	19.05	13.03	15.06	7.08	11.53	12.90	9.76	13.03	11.38	13.26	....
June	2.72	2.85	4.68	4.00	4.10	1.07	2.34	3.48	1.14	3.42	....
July	2.36	2.47	2.22	5.13	1.77	4.25	2.53	1.22	8.29	3.67	....
August	1.73	3.73	3.32	2.90	1.77	2.98	0.91	2.36	2.45	2.85	....
Total	6.81	9.05	10.22	12.12	7.64	8.30	5.78	7.06	11.88	9.94	....
September	4.70	5.05	4.68	1.40	1.34	2.93	2.16	5.36	0.88	2.84	....
October	3.71	0.54	2.40	3.67	4.48	2.95	5.20	3.99	3.22	3.29	5.80
November	2.82	2.54	3.18	3.23	1.52	3.72	4.27	4.30	3.06	2.94	1.60
Total	11.23	8.13	10.26	8.30	7.34	9.60	11.63	13.65	7.16	9.07	....
Yearly total	37.09	30.21	35.54	27.48	26.51	30.80	27.17	33.74	30.42	32.27	....

a Onondaga record.

b Mean of—

Mexico	2.59
Gouverneur	0.72
Potsdam	0.73
	3)4.04
	1.35

Table No. 69.—*Record of precipitation at Lowville for certain water years, as indicated, from 1827 to 1898, inclusive*—Continued.

Month.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	1871.
December	5.20	5.05	4.51	1.76	......	......	5.41	4.69	2.12	*a* 5.02	*b* 3.23
January	3.06	1.58	......	......	4.81	......	1.61	2.26	2.11	1.17	......
February	3.42	3.71	......	......	2.38	......	4.81	2.21	1.62	1.00	......
March	1.17	3.77	......	......	3.88	......	3.15	0.80	4.22	2.05	5.11
April	4.08	2.04	......	......	2.37	......	5.74	2.73	3.89	1.62	2.78
May	3.39	2.61	......	......	1.31	2.75	3.65	3.72	1.81	2.05	2.20
Total	20.32	18.76	......	......	......	......	24.37	16.41	15 77	12.91	......
June	3.64	2.84	......	......	6.30	0.19	4.34	2.98	3.20	2.07	1.94
July	4.05	1.85	......	......	4.44	1.69	1.42	3.78	2.74	5.40	2.53
August	2.43	3.51	......	......	......	2.88	4.96	3.35	4.84	4.61	3.58
Total	10.12	8.20	......	......	......	4.76	10.72	10.11	10.78	12.08	8.05
September	2.96	1.95	......	......	......	4.17	2.75	3.34	3.35	3.31	0.94
October	3.78	2.09	......	......	......	1.31	5.04	4.58	2.86	4.56	1.42
November	3.66	2.35	......	......	......	2.78	5.15	2.53	4.12	5.13	3.45
Total	10.40	6.38	......	......	......	8.26	12.94	10.45	10.33	13.00	5.81
Yearly total	40.84	33.34	......	......	......	......	48.03	36.97	36.88	37.99	......

Month.	1872.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	32 years' mean.
December	3.97	......	2.80	4.75	1.80	5.81	2.70	4.94	1.46	3.02	......
January	......	......	3.38	4.11	2.29	3.51	3.22	2.32	2.72	4.32	......
February	......	......	4.12	1.42	4.08	3.43	1.68	4.73	1.75	2.10	......
March	......	......	3.60	2.72	1.86	1.72	1.42	4.88	2.97	1.63	......
April	0.68	......	1.30	0.68	3.89	2.26	2.00	0.80	2.97	2.24	......
May	1.90	......	1.24	4.79	6.78	4.35	2.29	2.03	3.97	2.78	......
Total	......	......	16.44	18.47	20.70	21.08	13.31	19.70	15.84	16.09	......
June	6.40	......	4.10	5.86	1.90	2.75	1.69	1.83	3.40	2.57	......
July	4.39	......	7.46	4.94	2.79	1.34	2.28	3.50	2.96	1.60	......
August	......	......	2.30	8.76	8.65	1.66	3.93	2.45	3.27	3.61	......
Total	......	......	13.86	19.56	13.34	5.75	7.90	7.78	9.63	7.78	......
September	......	9.73	1.74	3.54	2.82	3.84	2.63	3.09	1.72	2.92	......
October	......	......	3.03	1.91	1.69	5.28	1.54	2.15	1.34	5.07	......
November	......	......	5.23	4.13	3.75	2.60	4.64	5.23	5.81	3.41	......
Total	......	......	10.00	9.58	8.26	11.72	8.81	10.47	8.87	11.40	......
Yearly total	......	......	40.30	47.61	42.30	38.55	30.02	37.95	34.34	35.27	35.04

Mean, 1891 to 1898, eight years, 38.29.

a Mean of Pierpont Manor 4.85
5.18
2)10.03
5.02

b December, 1861.

TABLE NO. 70.—*Record of precipitation at Lyons for the water years 1889 to 1898, inclusive.*

Month.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	*a*2.50	1.88	3.64	1.57	1.38	2.60	2.76	3.74	1.64	3.14	......
January	*b*3.53	2.92	1.09	2.80	2.23	2.45	2.12	3.57	2.27	4.82	......
February	2.59	2.76	1.52	1.39	3.18	2.55	2.17	4.28	0.95	1.63	......
March	2.10	0.94	3.27	3.18	1.22	2.03	0.90	5.25	2.37	2.37	......
April	3.39	2.25	2.08	1.17	1.67	2.07	1.54	1.02	2.14	1.99	......
May	3.15	4.48	1.33	4.06	4.88	5.31	3.26	2.27	1.84	*c*3.63	......
Total	17.35	15.23	12.93	14.17	14.56	17.01	12.74	20.13	11.21	17.58	......
June	6.22	3.77	1.19	5.72	3.35	2.35	3.39	2.42	2.95	2.86	......
July	6.03	4.41	2.42	2.94	4.24	2.11	2.59	*c*4.71	5.04	2.96	......
August	1.83	3.41	3.58	4.23	7.89	2.23	3.69	3.05	1.22	5.58	......
Total	14.08	11.59	7.19	12.89	15.48	6.69	9.67	10.18	9.21	11.40	......
September	2.72	9.61	1.16	0.81	2.03	4.15	1.67	3.72	1.18	3.09	......
October	3.58	4.66	3.58	1.20	1.91	2.91	0.95	1.26	0.48	4.38	......
November	3.90	2.81	1.99	3.34	1.05	2.07	2.76	3.24	3.46	3.00	......
Total	10.20	17.08	6.73	5.35	4.99	9.13	5.38	8.22	5.12	10.47	......
Yearly total	41.63	43.90	26.85	32.41	35.03	32.83	27.79	38.53	25.54	39.45	34.40

a Mean of—

Auburn	3.94
Geneva	1.24
	2)5.18
	2.59

b Geneva record.

c Rose record.

TABLE NO. 71.—*Record of precipitation at Malone for certain water years, as indicated from 1839 to 1896, inclusive.*

Month.	1839.	1840.	1841.	1842.	1843.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	Mean.
December	*a*0.72	1.07	2.34	*a*1.44	2.87	......	1.96	3.18	2.19	6.21	3.13	4.22	......
January	2.30	1.85	......	1.04	......	......	3.74	6.24	1.66	2.48	2.18	1.34	......
February	1.28	1.83	......	3.57	......	......	4.38	2.51	2.52	2.20	2.94	6.47	......
March	1.72	1.41	......	2.99	......	......	3.31	4.64	0.85	2.98	1.35	4.75	......
April	0.84	4.00	......	1.28	......	......	4.37	1.81	3.44	1.15	2.71	2.17	......
May	3.21	3.90	......	1.82	......	......	1.92	3.26	4.05	2.85	2.82	1.23	......
Total	10.07	14.06	......	12.14	......	......	19.68	21.64	14.71	17.87	15.13	20.21	......
June	3.59	2.47	......	4.10	......	......	4.45	6.81	3.29	4.76	3.09	4.57	......
July	3.85	2.72	......	5.11	......	3.20	4.80	7.69	5.17	4.87	3.08	5.71	......
August	0.96	2.36	......	1.39	......	......	4.86	9.57	9.98	1.05	7.75	3.63	......
Total	8.40	7.55	......	10.60	......	......	14.11	24.07	18.44	10.68	13.92	13.91	......
September	1.53	3.78	......	2.95	......	......	1.78	2.49	2.71	5.57	3.31	......	......
October	1.25	4.19	......	3.32	......	......	3.50	2.51	1.30	3.43	0.62	......	......
November	0.75	2.20	......	1.37	......	4.91	2.69	4.44	1.45	2.70	4.84	......	......
Total	3.53	10.17	......	7.64	......	......	7.97	9.44	5.46	11.70	8.77	......	......
Yearly total	22.00	31.78	......	30.38	......	......	41.76	55.15	38.61	40.25	37.82	......	37.22

a Mean of—

Potsdam	0.73	0.46
Gouverneur	0.72	2.42
	2)1.45	2.88
	0.72	1.44

TABLE NO. 72.—*Record of precipitation at Mexico for certain water years, as indicated from 1837 to 186–, inclusive.*

Month.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.
December	a1.75	2.73	2.59	a2.13	1.37	3.87	3.94	2.10	5.20	1.87	3.62	a3.97	3.88	2.91
January	1.70	2.77	......	1.91	3.08	1.95	1.74	3.60	2.45	1.42	......	2.40	2.00	......
February	1.63	1.84	......	1.24	2.25	4.85	3.41	0.65	3.70	1.65	......	1.00	0.47	......
March	2.12	0.96	......	1.06	1.58	2.44	6.65	2.60	2.75	1.35	......	2.13	1.27	......
April	0.77	0.86	......	1.75	2.95	1.90	1.82	1.61	0.92	0.77	......	1.06	1.04	......
May	2.51	5.13	......	1.64	1.08	1.90	2.17	4.31	3.10	2.07	......	4.34	2.23	......
Total	10.48	14.29	......	9.73	12.29	16.91	19.73	14.87	18.12	9.13	......	14.90	10.89	......
June	5.07	2.81	......	1.81	1.25	3.32	2.10	2.02	3.52	1.38	......	2.36	0.57	......
July	4.72	1.92	......	1.92	1.62	2.77	4.24	2.25	3.23	2.92	......	2.75	1.91	......
August	6.53	3.12	......	1.66	1.45	1.78	1.07	2.77	0.20	1.30	......	1.80	1.66	......
Total	16.32	7.85	......	5.39	4.32	7.88	7.41	7.04	6.95	5.60	......	6.91	4.14	......
September	2.95	1.55	......	2.05	3.60	5.49	2.47	0.55	2.59	2.15	......	4.59	2.71	......
October	3.55	4.47	......	1.33	1.71	3.15	4.17	5.90	3.60	6.81	......	2.37	6.28	7.28
November	3.20	4.15	......	1.71	4.65	3.14	3.76	1.00	1.61	5.48	......	1.06	4.02	4.99
Total	9.70	10.17	......	5.09	9.96	11.78	10.40	7.45	7.80	14.44	......	8.02	13.01	......
Yearly total	36.50	32.31	......	20.21	26.57	36.57	37.54	29.36	32.93	29.17	.....	29.83	28.04	......

Month.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	1861.	1·62.	Mean
December	4.60	5.34	7.25	3.18	2.00	4.70	5.16	5.77	4.75	7.00	......	1.10	......
January	2.37	5.78	2.55	4.32	3.70	3.83	3.09	2.26	3.75	......	......	3.48	......
February	3.86	2.16	3.52	3.12	3.74	4.16	4.61	3.80	1.72	3.29	......	2.74	......
March	1.52	4.10	3.46	2.35	3.50	2.66	3.84	1.37	5.89	......	......	4.75	......
April	2.70	1.01	3.40	4.51	2.47	2.16	6.43	3.90	4.86	......	......	1.83	......
May	2.45	2.60	3.98	3.06	2.79	3.65	3.87	3.89	2.50	......	......	1.75	......
Total	17.50	20.99	24.16	20.54	18.20	21.16	27.00	20.99	23.47	......	......	15.65	......
June	4.04	2.61	2.45	4.56	4.31	1.52	6.29	4.04	3.63	......	......	0.86	......
July	4.82	2.18	1.67	2.92	7.56	2.17	2.09	2.65	3.63	......	......	......	......
August	2.46	1.42	3.60	1.72	2.69	3.34	6.94	3.54	5.85	......	......	......	......
Total	11.32	6.21	7.72	9.20	14.56	7.03	15.32	10.23	13.11	......	......	......	......
September	2.62	4.40	5.04	4.84	5.35	5.95	2.52	3.28	3.00	......	......	......	......
October	3.84	3.34	3.45	2.99	5.26	4.19	5.09	2.28	2.64	......	......	......	......
November	5.04	2.86	4.25	3.00	2.48	3.37	6.80	3.59	4.33	......	1.91	......	......
Total	11.50	10.60	12.74	10.83	13.09	13.51	14.41	9.15	9.97	......	......	......	......
Yearly total	40.32	37.80	44.62	40.57	45.85	41.70	56.73	40.37	46.55	......	......	......	36.68

Means of—			
Gouverneur	....	1.48	3.24
Potsdam	0.81	1.09	.....
Fairfield	1.74	1.25	6.42
Belleville	2.80	.....	.....
Lowville	....	0.82	3.01
Cazenovia	....	.....	3.23
Utica	2.51	3.88	.....
Whitestown	....	2.36	.....
Onondaga	0.87	4.02	.....
	5)8.73	7)14.90	4)15.90
	1.75	2.13	3.97

Table No. 73.—*Record of precipitation at Middleburg for certain water years, as indicated from 1848 to 1892, inclusive.*

Month.	1848.	1849.	1871.	1872.	1873.	1888.	1889.	1890.	1891.	1892.	Mean.
December	a4.84	1.79	......	1.30	1.10	......	3.35	2.75	3.15	(3.70)	......
January	1.46	......	......	......	2.20	......	4.45	2.50	3.50	......	......
February	1.77	......	2.10	1.20?	2.60	......	2.05	2.15	5.00	......	......
March	2.26	......	6.90	1.50?	5.10	......	1.50	4.31	3.61	......	......
April	2.46	......	......	3.30	6.90	......	3.20	1.50	1.40	......	......
May	2.92	......	5.20	7.00	b1.65	......	3.35	4.15	3.00	......	......
Total	15.71	......	......	......	19.55	......	17.90	17.36	19.66	......	......
June	3.40	......	6.10	......	2.80	......	4.10	3.20	2.50	......	......
July	3.30	......	......	5.60	7.00	......	4.45	2.25	2.80	......	......
August	2.81	......	4.50	5.20	7.70	3.40	2.85	2.85	(6.20)	......	......
Total	9.51	......	......	......	17.50	......	11.40	8.30	11.50	......	......
September	2.83	......	0.80	3.60	2.60	4.30	3.00	5.35	0.70	......	......
October	2.88	......	1.30	8.00	7.20	4.60	2.40	5.50	3.00	......	......
November	2.56	......	3.00	1.55	5.10	2.90	4.45	3.00	(2.80)	......	......
Total	8.27	......	5.10	13.15	14.90	11.80	9.85	13.85	6.50	......	......
Grand total	33.49	......	......	......	51.95	......	39.15	39.51	37.66	......	40.36

a Mean of—

Fairfield	6.42
Hamilton	3.27
	2)9.69
	4.84

b Cooperstown record.

Table No. 74.—*Record of precipitation at Minaville for the water years 1868 to 1870, inclusive.*

Month.	1868.	1869.	1870.	Mean.
December	2.47	3.40	3.70	....
January	3.14	2.75	4.76	....
February	0.97	1.57	4.90	....
March	2.73	3.00	6.30	....
April	2.71	1.45	5.65	....
May	7.40	3.05	2.90	....
Total	19.42	15.22	28.21	....
June	3.30	4.40	3.50	....
July	1.10	5.05	3.65	....
August	2.89	2.15	2.39	....
Total	7.29	11.60	9.54	....
September	6.26	4.70	2.40	....
October	2.16	7.20	1.95	....
November	5.81	2.75	1.60	
Total	14.23	14.65	5.95	....
Yearly total	40.94	41.47	43.70	42.04

TABLE NO. 75.—*Record of precipitation at Minnewaska and Lake Mohunk for certain water years, as indicated from 1891 to 1898, inclusive.*

Month.	Lake Minnewaska.					Lake Mohunk.			Mean.
	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	
December	3.55	3.25	1.35	2.80	5.05	*a* 3.30	1.90	5.44	....
January	9.63	6.09	3.45	1.96	3.40	1.49	1.89	5.07	....
February	4.40	2.00	8.15	3.10	0.60	4.99	3.02	5.00	....
March	4.73	3.53	3.80	1.65	1.60	11.07	4.00	2.93	....
April	3.39	0.55	4.20	3.40	7.45	*b* 1.18	2.12	2.66	....
May	2.68	6.90	8.03	5.85	3.70	2.11	3.92	4.28	....
Total	28.38	22.32	28.98	18.76	21.80	24.14	16.85	25.38	....
June	4.00	5.55	3.05	1.01	3.31	2.22	2.29	2.07	....
July	9.15	6.24	1.60	3.11	1.90	4.32	14.71	....	....
August	4.65	9.82	4.66	1.87	....	2.70	4.11	8.19	....
Total	17.80	21.61	9.31	5.99	....	9.24	21.11	....	....
September	4.35	2.46	3.53	7.72	0.93	6.64	1.89	....	....
October	1.90	0.25	4.90	6.90	....	3.11	1.06	....	....
November	5.19	5.76	2.05	2.50	....	4.79	5.10	....	....
Total	11.44	9.07	10.48	17.12	....	14.54	8.05	....	....
Yearly total	57.62	53.00	48.77	41.87	....	47.92	46.01	....	49.20

a Honeymead Brook record.
b Wappingers Falls record.

TABLE NO. 76.—*Record of precipitation at Mount Morris for the water years 1890 to 1898, inclusive.*

Month.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	....	*a* 1.05	2.92	*a* 0.86	2.00	*b* 2.54	2.50	1.50	1.80	....
January	....	*a* 1.99	*a* 2.14	*a* 0.55	2.58	*b* 3.31	2.60	1.40	2.85	....
February	....	2.88	*a* 2.45	*a* 2.86	2.78	*b* 1.47	5.35	1.00	1.40	....
March	....	1.90	*a* 0.63	*a* 2.62	0.97	*b* 1.53	1.92	2.70	0.15	....
April	....	1.41	0.64	3.08	3.13	1.62	0.46	2.10	1.80	....
May	....	1.01	4.90	5.62	6.27	1.48	1.66	2.55	2.63	....
Total	....	10.24	13.68	15.59	18.82	11.95	14.49	11.25	10.63	....
June	....	2.04	4.77	0.87	2.08	2.67	2.82	2.10	2.40	....
July	1.43	2.95	2.05	1.97	1.51	1.74	4.91	2.20	*a* 2.09	....
August	2.49	3.66	5.34	5.20	2.27	3.41	1.85	0.20	4.56	....
Total	....	8.65	12.16	8.04	5.86	7.82	9.58	4.50	9.05	....
September	6.43	0.74	1.18	2.95	4.28	1.84	3.94	1.00	1.55	....
October	5.46	1.83	1.33	1.88	2.57	0.84	1.41	0.60	3.00	....
November	2.07	2.23	*a* 3.27	1.10	0.54	2.60	2.60	2.20	1.74	....
Total	11.96	4.80	5.78	5.93	7.39	5.28	7.95	3.80	6.29	....
Yearly total	....	23.69	31.62	29.56	32.07	25.05	32.02	19.55	25.97	27.44

a Avon record. *b* Mean of Western Plateau.

Table No. 77.—*Record of precipitation at Newark Valley for the water years 1891 to 1898, inclusive.*

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	a 3.58	4.12	0.77	2.80	2.09	2.43	1.22	2.85	....
January	3.43	4.11	1.40	2.45	2.67	1.30	1.25	4.04	....
February	2.75	1.16	2.86	2.80	0.78	4.55	1.34	2.04	....
March	4.37	4.60	2.70	1.52	1.07	3.98	2.74	2.26	....
April	2.47	1.01	3.49	4.63	2.70	0.39	3.08	3.72	....
May	0.57	6.96	6.66	6.50	3.23	2.95	4.01	5.48	....
Total	17.17	21.96	17.88	20.70	12.54	15.60	13.64	20.39	....
June	6.11	4.38	1.76	4.34	2.50	3.00	3.81	3.27	....
July	4.18	4.24	4.00	3.01	3.38	5.71	4.43	3.62	....
August	6.47	6.06	5.17	2.21	4.13	1.08	3.71	8.18	....
Total	16.76	14.68	10.93	9.56	10.10	9.79	11.95	15.07	....
September	1.47	1.64	5.96	5.05	2.13	3.24	4.71	2.33	....
October	4.75	1.84	2.68	6.42	1.14	4.26	0.36	6.69	....
November	3.44	2.88	0.75	2.23	2.49	2.21	3.82	3.11	....
Total	9.66	6.36	9.39	13.70	5.76	9.71	8.89	12.13	....
Yearly total	43.59	43.00	38.20	43.96	28.40	35.10	34.48	47.59	39.29

a Waverly record.

Table No. 78.—*Record of precipitation at New Lisbon for the water years 1891 to 1898, inclusive.*

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	a 3.97	4.78	1.00	2.38	1.92	4.04	0.95	4.20	....
January	4.11	4.40	1.65	2.13	2.03	0.86	1.14	4.37	....
February	3.56	1.50	4.86	1.75	1.98	4.31	1.53	2.13	....
March	2.09	3.44	2.12	1.40	1.41	3.96	2.90	1.68	....
April	1.89	1.25	3.30	1.50	3.21	0.80	2.63	2.77	....
May	2.50	7.27	4.90	4.82	2.50	2.42	4.40	3.92	....
Total	18.12	22.64	17.83	13.98	13.05	16.39	13.55	19.07	....
June	3.72	3.86	1.97	3.88	2.00	3.77	4.10	3.04	....
July	4.63	6.23	5.13	2.13	2.53	5.12	5.58	6.50	....
August	5.59	8.70	8.38	2.04	5.76	2.45	3.17	7.38	....
Total	13.94	18.79	15.48	8.05	10.29	11.34	12.85	16.92	....
September	1.39	2.76	4.05	5.74	2.16	5.07	3.19	4.95	....
October	3.26	1.61	1.25	4.67	1.45	2.09	0.73	7.19	....
November	2.55	3.63	0.95	2.00	2.98	2.96	4.04	3.64	....
Total	7.20	8.00	6.25	12.41	6.59	10.12	7.96	15.78	....
Yearly total	39.26	49.43	39.56	34.44	29.93	37.85	34.36	51.77	39.58

a Mean of—

Cooperstown	4.33
Oxford	3.61
	2) 7.94
	3.97

TABLE No. 79.—*Record of precipitation at North Hammond for certain water years, as indicated, from 1866 to 1898, inclusive.*

Month.	1866.	1867.	1868.	1869.	1870.	1871.	1872.	1889.	1890.
December	*a*2.65	6.11	2.94	1.97	4.60	2.50	2.31	*b*2.68	4.11
January	1.55	3.36	1.58	2.40	5.94	1.39	2.57	2.64	3.27
February	2.49	4.52	1.39	4.90	3.11	2.54	2.75	1.01	4.38
March	4.53	1.56	3.93	1.96	2.75	5.37	....	*c*0.91	1.81
April	3.07	5.60	0.99	0.95	0.65	4.60	....	2.17	1.78
May	*d*3.06	8.00	5.37	3.85	*d*1.01	2.19	....	2.35	3.59
Total	17.35	29.15	16.20	16.03	18.06	18.59	....	11.76	18.94
June	8.74	1.33	0.72	3.10	0.97	1.88	....	7.36	3.12
July	3.21	4.17	1.00	1.54	1.27	4.23	....	4.08	2.78
August	9.63	3.45	1.55	1.74	2.06	3.21	....	1.78	3.63
Total	21.58	8.95	3.27	6.38	4.30	9.32	....	13.22	9.53
September	10.44	1.10	5.60	5.30	3.13	0.69	....	2.48	3.66
October	4.14	5.08	1.59	7.24	6.72	*d*1.63	....	3.49	*e*2.29
November	6.78	3.17	6.37	3.77	2.14	3.01	....	3.11	2.85
Total	21.36	9.35	13.56	16.31	11.99	5.33	....	9.08	8.80
Yearly total	60.29	47.45	33.03	38.72	34.35	33.24	....	34.06	37.27

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	1.75	3.25	0.95	3.53	*f*3.47	4.72	1.02	2.51	....
January	3.20	2.58	2.28	2.80	3.58	1.06	1.47	2.57	....
February	3.04	1.34	1.83	0.92	1.18	3.20	1.35	2.75	....
March	5.08	2.05	0.98	2.68	1.41	3.34	4.82	2.08	....
April	1.80	1.89	3.52	1.31	2.70	1.33	2.57	1.44	....
May	1.04	4.24	6.03	4.07	1.41	2.78	3.91	3.08	....
Total	15.91	15.35	15.59	15.31	13.75	16.43	15.14	14.43	....
June	1.82	8.25	1.96	3.35	0.69	2.36	2.92	2.03	....
July	5.36	4.21	*g*3.32	3.83	2.94	2.43	4.33	0.68	....
August	5.18	11.78	6.75	1.08	3.48	4.06	2.19	5.06	....
Total	12.36	24.24	12.03	8.31	7.11	8.85	9.44	7.77	....
September	1.48	3.25	*g*2.50	2.92	2.70	4.50	1.70	4.41	....
October	3.08	1.39	*g*1.00	5.31	0.76	1.35	0.78	4.42	....
November	2.33	3.74	2.26	2.01	5.48	2.31	4.01	1.53	....
Total	6.89	8.38	5.76	10.24	8.94	8.16	6.49	10.36	....
Yearly total	35.16	47.97	33.38	33.86	29.80	33.44	31.07	32.56	37.23

a Mean of—

Theresa	2.81
Gouverneur	2.50
	2)5.31
	2.65

b Mean of—

Utica	3.12
Palermo	2.25
	2)5.37
	2.68

c Canton record.

d Gouverneur record.

e Mean of—

Dekalb Junction	2.30
Canton	2.28
	2)4.58
	2.29

f Mean of—

Dekalb Junction	1.90
Canton	2.35
Ogdensburg	2.69
	2)6.94
	3.47

g Mean of—

Dekalb Junction	5.44	3.13	1.36
Ogdensburg	1.20	1.88	0.63
	2)6.64	5.01	1.99
	3.32	2.50	1.00

TABLE NO. 80.—*Record of precipitation at North Volney for the water years 1872 to 1886, inclusive.*

Month.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.
December	....	2.65	3.00	1.95	1.80	3.05	1.90	8.35
January	....	2.90	6.05	2.35	4.25	2.60	3.80	2.80
February	....	1.65	3.07	2.55	4.70	0.30	3.20	2.80
March	....	6.97	2.90	2.20	3.30	3.80	2.75	2.00
April	....	2.75	3.65	2.95	2.05	1.45	2.95	0.65
May	....	2.00	1.85	2.20	1.10	1.15	3.15	1.65
Total	....	18.92	20.52	14.20	17.20	12.35	17.75	18.25
June	....	2.00	5.55	3.30	2.45	2.90	3.50	3.72
July	3.33	5.40	7.80	2.25	3.90	5.25	2.85	2.90
August	1.13	2.90	0.95	1.40	0.75	2.80	4.75	2.65
Total	....	10.30	14.30	6.95	7.10	10.95	11.10	9.27
September	3.66	2.90	3.25	4.25	4.65	2.70	2.20	2.63
October	6.20	5.94	3.10	3.25	3.80	2.75	5.80	1.85
November	2.38	3.50	3.45	2.70	3.85	4.10	5.05	5.60
Total	12.24	12.34	9.80	10.20	12.30	9.55	13.05	10.08
Yearly total	....	41.56	44.62	31.35	36.60	32.85	41.90	37.60

Month.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	Mean.
December	3.70	2.00	5.80	3.35	2.85	3.50	3.65	....
January	2.30	2.35	2.70	2.35	3.70	3.15	4.45	....
February	2.60	3.30	2.70	3.10	3.25	2.20	2.25	....
March	2.85	2.70	3.12	2.15	3.90	0.90	3.25	....
April	2.30	1.20	1.80	1.60	0.80	2.40	2.15	....
May	2.75	2.20	3.55	6.70	1.85	2.70	....	....
Total	16.50	13.75	19.67	19.25	16.35	14.85	....	....
June	2.35	2.60	3.33	4.55	1.15	3.05	....	....
July	3.15	2.90	1.00	3.95	2.50	4.35	....	....
August	4.55	*a* 1.84	2.95	1.50	3.20	2.20	....	....
Total	10.05	7.34	7.28	10.00	6.85	9.60	....	....
September	1.70	1.42	2.75	2.55	2.20	3.30	....	....
October	3.90	4.15	1.20	2.35	3.22	3.70	....	....
November	5.65	2.80	1.45	4.00	2.65	2.95	....	....
Total	11.25	8.37	5.40	8.90	8.07	9.95	....	....
Yearly total	37.80	29.46	32.35	38.15	31.27	34.40	....	36.15

a Mean of—

Oswego	1.69
Palermo	1.90
	2) 3.68
	1.84

TABLE No. 81.—*Record of precipitation at Number Four for the water years 1889 to 1898, inclusive.*

Month.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	a 2.68	4.26	3.32	4.57	3.28	5.92	3.10	5.32	2.59	4.60	....
January	7.09	6.64	4.05	6.58	2.46	3.87	4.78	3.04	3.15	5.55	....
February	5.42	4.49	3.67	3.37	2.44	3.43	2.57	7.93	3.21	3.12	....
March	2.41	3.24	3.52	3.24	2.27	3.40	2.59	6.55	4.25	2.14	....
April	2.38	2.96	2.36	1.77	3.98	1.89	2.79	1.84	3.93	3.27	....
May	3.10	7.98	1.57	5.83	6.30	4.40	3.17	2.16	3.99	3.71	....
Total	23.08	29.57	18.49	25.36	20.73	22.91	19.00	26.84	21.12	22.39	....
June	8.49	4.01	3.23	5.34	5.03	4.60	2.46	2.81	4.29	2.77	....
July	5.02	4.93	8.46	5.91	4.27	2.55	4.15	7.05	6.46	2.19	....
August	3.80	6.29	4.12	9.00	6.63	1.09	5.82	3.47	4.97	6.56	....
Total	17.31	15.23	15.81	20.25	15.93	8.24	12.43	13.33	15.72	11.52	....
September	3.65	8.46	2.21	4.06	5.46	5.57	6.42	5.01	3.37	5.17	....
October	4.30	3.66	3.52	3.47	2.55	6.70	2.46	3.44	2.38	6.78	....
November	5.26	4.24	4.84	6.06	3.60	2.70	6.39	4.75	6.45	3.49	....
Total	13.21	16.36	10.57	13.59	11.61	14.97	15.27	13.20	12.20	15.44	....
Yearly total	53.60	61.16	44.87	59.20	48.27	46.12	46.70	53.37	49.04	49.35	51.17

a Mean of—

Utica	3.12
Palermo	2.25
	2)5.37
	2.68

TABLE No. 82.—*Record of precipitation at Oneida for certain water years, as indicated, from 1863 to 1878, inclusive.*

Month.	1863.	1864.	1865.	1866.	1867.	1868.	1869.	1870.
December	....	....	4.16	3.72	3.70	3.74	4.00	4.82
January	3.48	....	3.80	1.80	2.65	4.30	3.93	2.39
February	2.25	....	3.36	5.26	1.00	2.50	4.41	5.60
March	3.70	....	2.82	2.97	a 3.63	4.80	3.45	3.40
April	3.37	....	6.26	1.72	7.39	3.99	4.34	2.44
May	....	....	5.40	4.37	12.61	10.05	5.69	3.36
Total	....	....	25.80	19.84	30.98	29.38	25.82	22.01
June	3.18	7.08	5.58	10.48	7.43	6.83	9.66	4.59
July	8.80	12.53	6.21	5.78	5.96	5.97	12.14	6.73
August	12.73	12.53	1.58	7.05	5.15	6.60	5.95	14.40
Total	24.71	32.14	13.37	23.31	18.54	19.40	27.75	25.72
September	....	....	9.16	9.08	5.67	10.70	5.14	7.20
October	....	7.11	7.84	3.08	4.12	2.47	8.93	a 5.06
November	....	....	6.23	7.36	2.93	10.64	a 4.18	a 3.05
Total	....	....	23.23	19.52	12.72	23.81	18.25	15.31
Yearly total	....	....	62.40	62.67	62.24	72.59	71.82	63.04

a Mean of—

South Trenton	5.30	6.61	8.00	3.39	4.76
Oswego	2.65	3.93	4.98	2.75	4.01
Palermo	2.95	2.00	2.20	3.00	2.90
	3)10.90	12.54	15.18	9.14	11.67
	3.63	4.18	5.06	3.05	3.89

TABLE NO. 82.—*Record for precipitation at Oneida for certain water years, as indicated, from 1863 to 1878, inclusive*—Continued.

Month.	1871.	1872.	1874.	1875.	1876.	1877.	1878.	Mean.
December	3.56	3.79	6.97		3.20	5.70	2.00	
January	1.14		9.96		3.95	4.80	4.72	
February	1.95		11.01	3.14	10.20	1.00		
March	6.55		6.49	3.83	9.78	3.19		
April	7.71		5.99	5.39	5.41	2.73		
May	4.12		4.60	4.17	4.17	2.77		
Total	25.03		45.02		36.71	20.19		
June	8.73		10.38	7.56	a 3.89	3.76		
July	4.49		12.61	6.39	6.57	7.36		
August	5.40		5.36	7.48	2.42	5.05		
Total	18.62		28.35	21.43	12.88	16.17		
September	1.71		5.95	6.40	7.33	3.15		
October	3.48		3.39	8.45	3.34	5.74		
November	5.83		4.32		2.20	4.09		
Total	11.02		13.66		12.87	12.98		
Yearly total	54.67		87.03		62.46	49.34		64.83

TABLE NO. 83.—*Record of precipitation at Onondaga Hollow for certain water years, as indicated, from 1826 to 1844, inclusive.*

Month.	1826.	1827.	1828.	1829.	1830.	1832.	1833.	1834.	1835.	1836.
December	a 1.95	1.96	3.63	1.81	1.14	b 2.06	2.90	1.60	c 2.02	0.94
January	4.23	7.86	1.55	3.26		1.22	1.08		0.93	6.29
February	2.23	2.60	1.42	0.51		1.44	1.43		1.43	2.07
March	3.16	2.32	1.10	0.39		0.54	2.28		1.31	0.53
April	2.18	2.05	1.25	1.94		0.85	2.08		4.28	1.48
May	0.50	1.77	0.54	1.30		1.86	4.73		1.07	6.73
Total	14.25	18.65	9.49	9.30		7.97	14.50		11.04	18.04
June	4.75	4.20	1.97	4.46		3.08	2.05		6.53	4.51
July	1.22	1.81	10.23	5.00		2.86	3.48		2.71	1.10
August	0.24	1.75	6.65	2.30		6.28	1.55		5.69	1.98
Total	6.31	7.76	18.85	11.76		12.22	7.08		14.93	7.59
September	1.99	1.58	3.63	2.48		2.16	3.20		1.96	3.2
October	2.91	4.97	3.15	2.13		2.22	1.84		3.27	3.57
November	1.20	3.46	2.49	2.01		2.79	1.38		2.31	1.97
Total	6.10	10.01	9.27	6.62		7.17	6.42		7.54	8.79
Yearly total	26.66	36.42	37.61	27.68		27.36	28.00		33.51	34.42

a Mean of all Decembers.

b Mean of—

Cazenovia	0.25
Utica	3.88
	2)4.13
	2.06

c Mean of

Cazenovia	2.30
Utica	1.89
Auburn	1.88
	3)6.07
	2.02

TABLE NO. 83.—*Record of precipitation at Onondaga Hollow for certain water years, as indicated, from 1826 to 1844, inclusive*—Continued.

Month.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	Mean.
December	0.87	1.14	0.84	4.02	2.59	2.49	2.59	1.83	....
January	1.30	0.71	2.93	1.95	2.29	1.04	2.40	1.35	....
February	2.13	0.77	1.25	1.24	0.49	1.80	2.37	0.43	....
March	2.01	0.61	1.53	2.71	2.42	1.87	4.24	1.70	....
April	1.08	1.50	2.26	2.54	2.71	1.76	1.78	1.56	....
May	2.27	5.87	4.81	2.35	2.01	1.65	1.73	5.08	....
Total	9.66	10.60	13.62	15.81	12.51	10.61	15.11	11.95	....
June	4.90	3.75	3.82	3.47	2.60	3.30	3.09	2.60	....
July	4.29	2.64	3.05	3.82	3.13	5.13	2.10	2.06	....
August	4.41	4.47	3.11	4.31	1.00	2.54	1.90	2.77	....
Total	13.60	10.86	9.98	11.60	6.73	10.97	7.09	7.43	....
September	2.36	2.17	1.80	4.03	1.88	5.11	5.06	1.82	....
October	4.25	4.43	0.92	3.23	1.32	3.87	5.19	5.38	....
November	2.62	2.65	2.97	1.81	4.10	3.94	2.72	1.27	....
Total	9.23	9.25	5.69	9.07	7.30	12.92	12.97	8.47	....
Yearly total	32.58	30.71	29.29	36.48	26.54	34.50	35.17	27.85	31.55

TABLE NO. 84.—*Record of precipitation at Oswego for certain water years, as indicated, from 1844 to 1898, inclusive.*

Month.	1844.	1845.	1846.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.
December	a2.08	3.71	3.62	b3.88	2.09	2.90	4.41	4.09	....	1.69	1.47
January	1.43	3.01	2.30	1.16	1.68	2.61	2.76	1.17	....	1.90	4.95
February	0.19	2.68	2.93	1.15	1.08	2.31	2.14	4.12	....	1.82	2.90
March	1.54	0.85	1.55	2.62	0.37	3.97	3.66	0.89	....	1.20	1.50
April	1.40	2.48	1.29	1.65	3.30	1.91	0.68	3.04	....	0.70	2.02
May	3.74	2.39	1.82	3.00	3.04	1.31	0.86	2.01	....	0.72	2.08
Total	10.38	15.12	13.51	13.46	11.65	15.01	14.51	15.32	....	8.03	14.92
June	8.20	4.73	1.38	1.66	2.03	2.55	4.06	0.72	....	3.60	1.71
July	1.42	1.58	....	0.69	6.09	2.37	1.18	0.13	....	5.20	3.64
August	6.50	a0.38	....	1.61	1.25	1.32	0.53	....	....	1.65	2.12
Total	16.12	6.69	....	3.96	9.37	6.24	5.77	....	....	10.45	7.47
September	0.54	3.63	....	2.26	2.40	1.74	3.31	....	....	2.02	6.40
October	4.89	5.60	....	6.30	5.59	2.48	4.80	....	0.82	3.40	1.50
November	1.02	2.65	....	2.77	4.81	4.97	4.47	....	1.09	2.25	c2.66
Total	6.45	11.88	....	11.33	12.80	9.19	12.58	....	....	7.67	10.56
Yearly total	32.95	33.69	....	28.75	33.82	30.44	32.86	....	....	26.15	32.95

a Mean of—

Mexico	2.10	0.20
Sacketts Harbor	2.06	0.57
	2)4.16	0.77
	2.08	0.38

b Mexico record.

c Mean of—

Palermo	3.30
Pierpont Manor	2.03
	2)5.33
	2.66

Table No. 84.—*Record of precipitation at Oswego for certain water years, as indicated, from 1844 to 1898, inclusive*—Continued.

Month.	1857.	1858.	1859.	1860.	1861.	1862.	1863.	1864.	1865.	1866.	1867.
December	......	5.54	......	6.41	[a]3.37	1.61	2.75	3.75	4.24	2.83	4.85
January	......	2.98	......	......	2.99	3.55	3.61	4.85	3.95	1.14	4.28
February	......	3.94	......	......	3.85	3.56	2.80	3.01	3.61	2.85	3.32
March	......	1.76	7.07	......	4.20	5.49	2.82	3.16	4.86	2.31	2.65
April	......	4.35	7.03	......	4.74	2.93	6.25	4.27	3.58	3.33	3.62
May	4.60	......	4.90	......	5.95	3.19	5.00	6.73	2.60	2.88	6.57
Total	......	......	......	......	25.10	20.33	23.23	25.77	22.84	15.34	25.27
June	......	......	3.15	......	2.20	3.10	4.00	0.88	5.95	4.81	1.41
July	1.57	......	5.95	......	7.69	5.51	4.35	1.00	2.35	2.33	1.94
August	5.28	......	3.21	......	1.65	2.51	5.25	6.66	1.13	3.73	2.53
Total	......	......	12.31	......	11.54	11.12	13.60	8.54	9.43	10.87	5.88
September	1.98	......	3.86	......	6.86	3.70	4.45	1.83	3.30	5.31	2.19
October	4.60	......	2.31	......	6.30	[a]4.96	5.48	5.72	6.32	3.77	1.28
November	5.61	......	3.65	......	2.01	3.80	8.40	4.44	2.84	5.92	1.67
Total	12.19	......	9.82	......	15.17	12.46	18.33	11.99	12.46	15.00	5.14
Yearly total	......	......	......	......	51.81	43.91	55.16	46.30	44.73	41.21	36.29

Month.	1868.	1869.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.	1878.
December	3.78	5.12	4.60	3.33	1.30	1.07	3.34	1.44	1.62	1.02	2.34
January	5.49	2.30	3.28	2.15	1.48	1.35	5.60	2.40	3.91	2.31	4.16
February	2.35	4.50	1.98	1.68	1.18	0.28	1.89	1.84	4.51	0.22	2.98
March	3.40	4.10	2.92	2.94	2.43	5.47	1.64	1.34	3.08	4.48	4.05
April	1.53	2.00	1.38	3.24	1.44	2.62	2.26	2.08	2.61	1.66	3.42
May	3.35	2.08	0.83	1.32	2.72	1.41	2.08	3.38	1.22	0.54	3.69
Total	19.90	20.10	14.99	14.66	10.55	12.20	16.81	12.48	16.95	10.23	20.64
June	3.14	3.92	2.15	2.20	4.48	1.91	4.98	3.03	4.01	3.33	3.28
July	1.93	6.67	4.72	2.88	1.84	3.71	7.62	3.43	3.30	5.89	3.91
August	3.13	4.21	3.50	5.92	0.71	2.46	0.29	2.46	0.45	2.19	4.41
Total	8.20	14.80	10.37	11.00	7.03	8.08	12.89	8.92	7.76	11.41	11.60
September	4.71	3.65	2.28	1.00	2.44	2.39	3.19	4.23	4.13	2.83	2.62
October	0.92	5.10	4.98	1.44	5.91	6.57	2.05	3.04	3.41	2.37	7.55
November	7.44	3.93	2.75	2.96	1.91	1.78	1.89	2.56	2.55	4.04	5.27
Total	13.07	12.68	10.01	5.40	10.26	10.74	7.13	9.83	10.09	9.24	15.44
Yearly total	41.17	47.58	35.37	31.06	27.84	31.02	36.83	31.23	34.80	30.88	47.68

[a] Mean of—

Palermo	4.20	7.90
Pierpont Manor	2.96	3.26
Sacketts Harbor	2.96	3.72
	3)10.12	14.88
	3.37	4.96

TABLE NO. 84.—*Record of precipitation at Oswego for certain water years, as indicated, from 1844 to 1898, inclusive*—Continued.

Month.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.
December	10.49	5.98	4.24	6.78	4.90	4.08	2.61	3.87	2.33	2.28	2.21
January	1.59	3.09	4.15	4.46	1.16	6.49	2.02	3.29	0.92	2.01	4.25
February	2.92	4.81	4.74	3.30	2.76	2.98	1.22	2.19	3.48	1.62	2.17
March	2.54	4.17	5.08	3.28	0.84	3.81	0.48	3.73	1.21	1.79	0.55
April	0.85	2.28	1.19	2.08	1.39	0.88	1.86	3.66	1.58	2.09	2.85
May	1.90	4.06	2.41	4.83	7.03	2.39	3.37	1.92	1.03	1.56	1.61
Total	20.29	24.39	21.81	24.73	18.08	20.63	11.56	18.66	10.55	11.35	13.64
June	3.49	3.27	2.98	3.72	4.58	1.48	3.94	1.03	2.72	2.60	9.81
July	3.56	1.74	1.73	1.12	3.21	1.90	4.89	4.24	1.82	2.32	3.02
August	3.51	3.25	1.69	3.09	2.16	1.71	2.37	2.58	1.69	4.56	1.02
Total	10.56	8.26	6.40	7.93	9.95	5.09	11.20	7.85	6.23	9.48	13.85
September	2.95	1.51	0.76	2.42	2.32	1.92	3.62	4.30	1.91	5.27	2.52
October	1.67	4.32	4.61	0.50	1.94	3.21	3.33	2.12	2.39	3.24	3.57
November	5.64	6.45	3.13	2.40	3.02	2.09	2.17	4.07	2.38	3.52	5.43
Total	10.26	12.28	8.50	5.32	7.28	7.22	9.12	10.49	6.68	12.03	11.52
Yearly total	41.11	44.94	36.71	37.98	35.31	32.94	31.88	37.00	23.46	32.86	39.01

Month.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	3.30	1.63	4.09	1.53	3.84	3.14	5.23	3.16	3.60	......
January	4.46	3.01	2.10	2.06	3.24	2.64	2.04	6.05	5.16	......
February	3.25	2.81	2.29	2.11	3.92	2.30	4.90	1.26	2.61	......
March	1.85	4.15	1.74	1.23	1.95	1.66	4.79	4.19	2.08	......
April	2.16	1.68	0.88	3.17	1.94	2.07	1.06	2.46	2.32	......
May	4.61	1.08	4.12	4.53	4.66	3.25	2.46	2.76	4.14	......
Total	19.63	14.36	15.22	14.63	19.55	15.06	20.48	19.88	19.91	......
June	2.43	1.58	6.95	2.20	3.70	1.20	1.57	3.56	1.12	......
July	4.18	4.10	4.00	1.16	1.86	1.67	5.89	3.15	3.23	......
August	2.19	2.11	4.38	6.47	0.90	3.38	3.00	1.70	3.27	......
Total	7.80	7.79	15.33	9.83	6.46	6.25	10.46	8.41	7.62	......
September	6.33	1.28	1.52	2.81	3.45	2.25	4.05	0.81	4.40	......
October	4.64	2.89	2.00	2.26	4.20	2.39	1.45	0.51	5.53	......
November	4.13	2.66	3.30	2.94	3.48	4.44	3.95	6.56	3.33	......
Total	15.10	6.83	6.82	8.01	11.13	9.08	9.45	7.88	13.26	......
Yearly total	42.53	28.98	37.37	32.47	37.14	30.39	40.39	36.17	40.79	36.65

TABLE NO. 85.—*Record of precipitation at Oxford for certain water years, as indicated, from 1829 to 1898, inclusive.*

Month.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838	1839.	1840.
December	*a*0.41	2.52	2.94	0.94	3.87	1.61	2.79	0.90	2.67	1.65	1.03	2.49
January	3.71	2.07	2.71	2.30	1.85	0.92	2.35	5.11	2.39	1.64	4.97	2.37
February	2.46	0.73	1.67	5.81	1.65	1.29	1.68	2.48	1.74	1.05	1.23	3.09
March	2.42	3.93	1.21	1.04	0.80	0.96	1.93	0.54	3.30	1.14	1.74	2.80
April	5.07	1.56	1.93	1.71	0.33	1.57	5.27	2.14	0.77	1.68	3.05	4.20
May	1.99	3.43	1.23	1.92	6.15	3.27	2.14	3.70	5.23	6.15	4.96	4.66
Total	16.06	14.24	11.69	13.72	14.65	9.62	16.16	14.87	16.10	13.31	16.98	19.61
June	3.00	5.04	4.37	2.63	2.47	4.73	5.72	5.84	4.12	3.72	4.56	4.10
July	3.17	4.50	4.26	0.70	3.66	3.59	3.46	6.96	4.68	2.86	5.20	3.12
August	3.84	0.86	4.13	5.38	3.48	3.43	5.38	3.04	3.37	3.70	2.12	4.45
Total	10.01	10.40	12.76	8.71	9.61	11.75	14.56	15.84	12.17	10.28	11.88	11.67
September	2.69	1.93	3.75	1.62	4.11	2.03	1.79	2.93	2.55	3.50	3.05	3.39
October	3.41	2.21	3.52	1.64	4.38	3.17	5.12	4.35	5.13	3.65	0.67	4.99
November	2.43	4.59	0.91	2.38	2.20	1.79	2.92	1.44	1.67	3.10	2.74	1.40
Total	8.53	8.73	8.18	5.64	10.69	6.99	9.83	8.72	9.35	10.25	6.46	9.78
Yearly total	34.60	33.37	32.63	28.07	34.95	28.36	40.55	39.43	37.62	33.84	35.32	41.06

Month.	1841.	1842.	1843.	1844.	1845.	1846.	1850.	1851.	1852.	1853.	1854.	1855.
December	2.35	4.27	3.97	1.82	1.18	1.28	......	4.46	2.54	4.38	1.26	2.55
January	3.78	1.80	2.50	1.81	2.57	......	......	1.02	2.13	2.83	1.97	3.40
February	0.49	4.31	2.61	0.21	1.22	......	......	5.16	1.98	4.13	3.17	1.57
March	3.86	3.90	4.01	1.82	2.87	......	......	1.49	2.56	2.10	2.76	1.10
April	4.23	2.97	4.52	1.33	2.77	......	......	4.28	2.94	3.85	7.11	4.43
May	2.02	1.49	1.04	6.18	2.44	......	......	4.20	3.14	5.70	3.22	3.80
Total	16.73	18.74	18.65	13.17	13.05	......	......	20.61	15.29	23.00	19.49	16.65
June	2.42	4.52	5.39	1.63	5.08	......	......	5.02	3.33	3.48	2.10	10.93
July	3.13	4.20	3.76	8.29	3.04	......	......	2.78	3.52	5.68	4.04	5.21
August	3.90	4.93	4.26	3.61	1.61	......	......	1.92	2.71	4.94	2.08	4.44
Total	9.45	13.65	13.41	13.53	9.73	......	......	9.72	9.56	14.10	8.22	20.58
September	2.94	6.96	4.41	3.21	4.34	......	......	2.92	3.22	7.76	4.77	2.18
October	1.32	2.67	4.79	3.53	3.90	......	2.11	1.70	2.62	3.21	*b*3.11	4.26
November	4.10	3.58	2.12	2.07	2.20	......	2.55	4.85	4.95	3.43	*b*2.71	2.98
Total	8.36	13.21	11.32	8.81	10.44	......	......	9.47	10.79	14.40	10.59	9.42
Yearly total	34.54	45.60	43.38	35.51	33.22	......	......	39.80	35.64	51.50	38.30	46.65

a Mean of-
Hamilton 0.37
Hartwick 0.45
2)0.82
0.41

b Cooperstown record.

TABLE NO. 85.—*Record of precipitation at Oxford for certain water years, as indicated, from 1829 to 1898, inclusive*—Continued.

Month.	1856.	1857.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean
December	3.56	1.67	*a* 2.36	3.61	5.38	1.37	3.28	2.60	4.23	1.72	4.01	......
January	1.46	......	4.20	4.83	6.47	2.57	2.85	3.46	1.99	1.76	4.76	......
February	0.60	......	3.73	4.15	1.66	4.47	2.46	2.00	4.97	2.09	3.11	......
March	1.37	......	4.48	2.78	4.87	2.58	1.86	2.13	5.56	4.08	2.75	......
April	2.98	......	3.64	2.44	1.74	4.89	2.79	2.76	0.77	3.76	4.90	......
May	3.57	......	10.04	1.39	9.37	6.23	5.03	2.78	3.53	5.47	3.90	......
Total	13.54	......	28.45	19.20	29.49	22.01	18.27	15.73	21.05	18.88	23.43	......
June	1.92	......	5.27	5.44	4.12	3.70	4.02	1.74	2.96	4.80	3.58	......
July	2.73	......	2.25	4.27	5.62	6.01	2.73	2.48	5.37	8.04	3.41	......
August	4.94	......	7.44	6.02	7.90	7.37	2.36	4.59	2.71	2.68	9.82	......
Total	9.59	......	14.96	15.73	17.64	17.08	9.11	8.81	11.04	15.52	16.81	......
September	4.76	......	7.67	2.72	2.50	3.94	6.11	2.64	2.15	3.13	4.99	......
October	0.91	......	6.21	4.42	1.62	1.46	5.97	1.06	2.69	0.80	7.08	......
November	2.22	......	2.09	2.56	3.44	1.72	2.58	3.95	2.66	4.85	4.58	......
Total	7.89	......	15.97	9.70	7.56	7.12	14.66	7.65	7.50	8.78	16.65	......
Yearly total	31.02	......	59.38	44.63	54.69	46.21	42.04	32.19	39.59	43.18	56.89	39.80

a Mean of—

Cooperstown	2.68
Ithaca	2.46
S. Kortright	1.94
	3)7.08
	2.36

TABLE NO. 86.—*Record of precipitation at Palermo for the water years 1854 to 1898, inclusive.*

Month.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	1861.	1862.	1863.	1864.	1865.
December	*a* 3.18	2.20	2.60	5.20	5.50	3.00	6.50	4.20	4.20	2.60	5.60	5.10
January	2.60	2.50	2.50	3.90	2.90	2.40	2.60	3.20	3.30	3.60	4.60	3.40
February	3.00	2.10	1.20	2.00	3.90	1.50	3.40	3.30	3.70	2.70	3.00	2.30
March	2.00	1.90	1.00	3.20	1.70	7.00	3.30	4.90	5.40	2.90	2.90	5.10
April	2.60	2.30	2.10	2.10	4.50	7.00	2.00	4.20	2.90	6.20	4.50	2.70
May	1.30	2.90	3.60	4.60	2.30	4.90	2.50	4.10	3.10	5.10	6.50	3.30
Total	14.68	13.90	13.00	21.00	20.80	25.80	20.30	23.90	22.60	23.10	27.10	21.90
June	3.50	5.80	1.50	8.50	3.50	3.20	6.80	3.30	3.00	2.30	0.70	8.80
July	3.00	4.50	2.10	1.50	5.60	5.90	2.90	3.80	5.50	4.20	1.10	3.00
August	1.50	1.40	3.30	3.30	3.10	3.20	2.60	3.60	2.40	5.30	6.40	1.10
Total	8.00	11.70	6.90	13.30	12.20	12.30	12.30	10.70	10.90	11.80	8.20	12.90
September	4.70	1.80	5.90	2.20	3.60	3.80	4.70	4.10	3.50	2.50	2.70	4.20
October	4.90	4.90	4.10	2.50	2.20	2.40	4.70	4.60	7.90	3.50	6.00	5.60
November	2.80	1.20	3.30	5.60	3.30	3.50	5.20	4.50	3.70	4.30	5.90	3.35
Total	12.40	7.90	13.30	10.30	9.10	9.70	14.60	13.20	15.10	10.30	14.60	13.15
Yearly total	35.08	33.50	33.20	44.60	42.10	47.80	47.20	47.80	48.60	45.20	49.90	47.95

a Mexico record.

Table No. 86.—*Record of precipitation at Palermo for the water years 1854 to 1898, inclusive*—Continued.

Month.	1866.	1867.	1868.	1869.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.
December	3.10	6.05	3.00	6.80	2.90	3.10	4.20	2.40	4.80	1.60	3.50	4.91
January	1.56	4.70	4.50	1.50	4.30	2.70	1.70	3.10	6.50	0.30	4.10	3.50
February	7.20	2.50	2.90	3.90	4.10	1.70	1.30	1.85	3.40	2.41	5.40	0.10
March	2.35	2.95	2.60	1.90	3.80	2.61	2.50	6.10	2.40	3.40	3.50	2.70
April	2.90	2.70	1.50	1.30	1.10	2.80	1.10	1.03	4.10	1.50	2.60	1.70
May	2.70	6.90	2.60	3.10	0.30	0.60	1.50	1.40	1.80	1.30	1.10	0.40
Total	19.81	25.80	17.10	18.50	16.50	13.51	12.30	15.88	23.00	10.51	20.20	13.31
June	4.80	1.60	2.80	3.00	0.70	2.10	3.30	0.80	4.80	3.20	2.90	2.50
July	2.80	2.40	0.70	4.70	3.70	1.40	3.70	6.10	6.60	1.90	3.60	4.90
August	0.41	1.60	2.70	2.60	0.50	5.20	1.10	2.30	0.60	1.60	1.00	2.54
Total	8.01	5.60	6.20	10.30	4.90	8.70	8.10	9.20	12.00	6.70	7.50	9.94
September	7.30	2.30	4.10	3.80	3.75	1.20	3.30	2.90	3.20	4.20	4.40	2.60
October	4.30	1.00	1.40	5.10	2.20	1.20	6.30	5.70	3.40	3.10	3.60	3.00
November	6.60	1.40	6.25	2.00	3.00	3.20	3.30	3.50	3.90	3.60	3.50	3.71
Total	18.20	4.70	11.75	10.90	8.95	5.60	12.90	12.10	10.50	10.90	11.50	9.31
Yearly total	46.02	38.10	35.05	39.70	30.35	27.81	33.30	37.18	45.50	28.11	39.20	32.56

Yearly mean, twenty-three years, 1854 to 1876, 30.96.

Month.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
December	3.30	7.95	3.34	1.88	5.40	3.51	2.63	3.42	3.93	2.97	2.45
January	3.60	3.10	2.21	2.69	2.95	2.95	0.16	3.41	3.90	5.39	3.53
February	2.30	4.89	2.49	3.34	2.50	3.01	3.60	2.55	2.36	2.03	1.91
March	2.52	1.75	1.82	2.75	4.22	1.27	3.23	0.68	1.68	1.08	1.89
April	3.00	0.26	1.66	0.88	1.67	1.16	0.68	1.00	2.13	1.12	2.30
May	3.20	1.79	2.57	1.48	2.58	5.87	1.28	2.29	1.07	1.87	1.17
Total	17.92	19.74	14.09	13.02	19.32	17.77	11.58	13.35	15.07	14.46	13.25
June	3.20	3.49	2.12	2.04	2.92	4.21	1.27	2.92	3.44	2.27	2.26
July	2.70	3.10	3.54	2.35	0.64	3.17	1.62	3.85	1.83	2.65	3.13
August	5.50	2.36	3.82	1.99	2.82	1.29	2.19	2.98	2.30	1.91	3.46
Total	11.40	8.95	9.48	6.38	6.38	8.67	5.08	9.75	7.57	6.83	8.85
September	1.60	1.57	1.04	1.34	1.85	1.83	1.91	3.99	3.70	2.33	4.23
October	5.35	1.15	2.87	3.81	0.30	1.80	2.65	3.12	1.85	1.93	2.20
November	4.05	4.38	5.75	1.82	1.01	3.57	2.18	2.50	4.31	3.25	3.45
Total	11.00	7.10	9.66	6.97	3.16	7.20	6.74	9.61	9.86	7.51	9.88
Yearly total	40.32	35.79	33.23	26.37	28.86	33.64	23.40	32.71	32.50	28.80	31.98

Month.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	2.25	2.23	3.48	4.05	1.35	3.22	2.27	6.01	2.36	4.08	......
January	3.48	4.11	2.44	3.11	3.07	3.40	1.96	2.00	6.78	2.91	......
February	2.83	2.62	3.45	2.23	3.99	3.14	2.05	5.13	1.14	2.50	......
March	2.50	1.49	3.80	2.47	1.32	1.80	0.88	3.67	4.15	1.26	......
April	2.05	2.00	1.73	1.09	3.66	1.75	0.52	0.41	1.49	1.75	......
May	1.17	4.75	0.44	4.62	4.72	6.04	2.90	2.36	2.99	4.10	......
Total	14.37	17.20	15.34	17.57	18.11	19.35	10.58	19.58	18.91	16.60	......
June	7.17	2.60	1.03	6.55	2.26	3.56	1.92	2.31	4.07	1.20	......
July	3.61	3.68	4.83	5.60	1.49	1.85	2.24	5.07	4.22	1.60	......
August	1.20	1.95	2.05	7.45	5.51	1.55	3.61	2.13	1.00	2.93	......
Total	11.98	8.23	7.91	19.60	9.26	6.96	7.77	9.51	9.29	5.73	......
September	2.70	7.55	1.66	2.74	2.80	3.44	2.20	2.51	0.69	4.08	......
October	3.28	4.19	3.51	2.93	2.24	4.41	2.59	2.02	0.40	5.14	......
November	4.11	3.95	2.88	3.97	2.32	4.14	2.83	3.60	8.17	3.25	......
Total	10.09	15.69	8.05	9.64	7.36	11.99	7.62	8.13	9.26	12.47	......
Yearly total	36.44	41.12	31.30	46.81	34.73	38.30	25.97	37.22	37.46	34.80	37.01

Yearly mean, twenty two years, 1877 to 1898, 33.83.

TABLE NO. 87.—*Record of precipitation at Pen Yan for the water years 1829 to 1867, inclusive.*

Month.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.
December	a0.77	1.80	1.86	1.06	2.06	1.76	1.05	0.68	0.74	1.74	0.65	1.99	2.10	1.44
January	2.13	1.10	1.40	2.16	0.86	0.39	0.96	3.12	1.82	0.78	2.28	1.46	2.22	0.71
February	1.80	0.87	1.80	1.08	1.37	0.48	0.87	1.62	2.52	1.12	2.11	1.52	0.62	1.41
March	2.41	2.13	2.26	2.19	0.88	1.28	1.25	1.09	0.90	1.43	0.71	3.76	1.82	3.53
April	3.14	3.28	1.67	3.20	2.03	1.52	3.47	1.97	1.52	2.11	2.16	3.58	3.00	3.12
May	2.06	3.56	2.11	2.21	5.25	3.00	1.39	5.66	3.84	6.33	3.29	3.00	2.29	1.67
Total	12.31	12.74	11.10	11.90	12.45	8.43	8.99	14.14	11.34	13.51	11.20	15.31	12.05	11.87
June	3.41	4.60	3.30	4.01	2.21	3.74	4.86	3.42	2.96	5.41	5.26	3.26	3.35	2.47
July	3.20	3.42	5.46	2.90	3.86	2.69	2.77	0.61	1.29	4.18	4.86	3.83	2.79	2.26
August	3.54	2.21	3.60	2.16	2.82	1.31	4.61	2.69	3.40	2.92	3.07	1.51	1.18	3.89
Total	10.15	10.23	12.36	9.07	8.89	7.74	12.24	6.72	7.65	12.51	13.19	8.60	7.32	8.62
September	4.48	2.60	2.90	3.46	2.16	2.09	1.78	3.39	0.82	1.82	2.64	2.07	2.95	5.72
October	2.38	1.28	2.04	3.10	1.62	3.33	2.18	2.32	2.67	2.18	1.17	2.05	0.68	2.02
November	2.04	3.16	2.30	2.17	1.07	1.51	1.69	1.22	1.08	2.50	1.76	1.40	1.71	2.70
Total	8.90	7.04	7.24	8.73	4.85	6.93	5.65	6.93	4.57	6.50	5.57	5.52	5.34	10.44
Yearly total	31.36	30.01	30.70	29.70	26.19	23.10	26.88	27.79	23.56	32.52	29.96	29.43	24.71	30.93

Month.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.
December	2.00	1.22	1.00	0.53	1.27	4.00	3.17	1.38	3.04	2.71	2.98	1.33	1.33
January	2.54	1.13	1.68	1.20	1.49	0.99	0.57	1.70	1.12	0.90	0.75	1.06	2.00
February	1.15	0.63	3.17	3.37	2.95	0.38	0.54	1.24	0.68	b1.30	2.28	1.25	1.56
March	1.44	1.45	1.81	1.83	0.49	1.18	0.85	1.64	1.24	0.55	1.00	1.89	0.67
April	2.90	1.00	2.06	1.14	1.73	0.63	0.48	1.07	2.66	2.22	3.51	4.11	2.85
May	1.51	3.07	1.49	1.14	2.39	3.36	3.12	3.47	4.18	3.24	2.98	1.47	3.02
Total	11.54	8.50	11.21	9.21	10.32	10.54	8.73	10.50	12.92	10.92	13.50	11.11	11.43
June	3.35	0.96	2.36	3.08	1.53	2.36	2.2	2.86	3.05	3.70	1.33	1.69	5.96
July	1.47	4.63	1.62	2.21	2.88	3.19	1.6	4.35	4.00	2.94	0.82	0.60	4.56
August	2.95	1.28	1.59	3.93	0.63	2.78	1.69	1.43	2.06	1.85	7.37	1.89	1.70
Total	7.77	6.87	5.57	9.22	5.04	8.33	5.49	8.64	9.11	8.49	9.52	4.18	12.22
September	5.67	0.97	1.78	2.25	3.75	1.97	1.37	3.66	1.42	1.54	5.32	1.51	1.34
October	2.72	2.80	3.09	5.15	3.64	0.87	6.29	4.49	1.15	2.22	1.20	1.50	3.50
November	2.26	1.18	3.22	2.36	2.24	1.69	2.88	2.77	2.54	1.94	1.58	1.36	1.28
Total	10.65	4.95	8.09	9.76	9.63	4.53	10.54	10.92	5.11	5.70	8.10	4.37	6.12
Yearly total	29.96	20.32	24.87	28.19	24.99	23.40	24.76	30.06	27.14	25.11	31.12	19.66	29.77

a Mean of

Auburn	1.05
Ithaca	0.50
	2)1.55
	0.77

TABLE NO. 87.—*Record of precipitation at Pen Yan for the water years 1829 to 1867, inclusive*—Continued.

Month.	1856.	1857.	1858.	1859.	1860.	1861.	1862.	1863.	1864.	1865.	1866.	1867.	Mean
December	1.52	1.92	2.12	1.67	3.19	0.79	0.87	1.74	1.73	1.63	1.19	1.03	......
January	1.79	0.79	0.67	0.87	0.58	0.81	2.58	2.85	1.45	1.35	0.52	1.01	......
February	0.45	1.07	0.91	0.91	0.52	2.26	1.66	3.02	0.69	2.39	1.55	0.73	......
March	1.50	1.09	0.97	2.23	1.56	1.48	4.15	1.45	2.30	2.12	2.08	1.47	......
April	1.86	4.79	2.60	4.50	1.47	3.63	1.32	0.90	2.37	2.24	1.52	3.79	......
May	1.78	3.37	3.66	1.25	1.62	3.02	1.68	3.48	5.20	3.75	2.17	8.23	......
Total	8.90	13.03	10.93	11.43	8.94	11.99	12.26	13.44	13.74	13.48	9.03	16.26	......
June	3.10	11.03	2.81	3.06	2.01	0.73	3.92	5.10	1.41	3.63	4.42	a2.05	......
July	3.25	2.81	3.73	2.91	3.83	5.29	4.98	10.23	1.88	2.64	1.30	0.49	......
August	1.03	4.87	2.97	3.95	3.88	4.00	1.35	4.30	7.22	1.84	3.38	1.34	......
Total	7.38	18.71	9.51	9.92	9.72	10.02	10.25	19.63	10.51	8.11	9.10	3.88	......
September	2.17	1.63	2.81	3.39	3.04	6.05	1.33	1.13	2.05	5.93	4.56	1.54	......
October	1.10	6.56	1.49	1.52	3.30	3.56	4.37	2.08	3.73	2.98	1.64	1.97	......
November	1.71	4.23	2.49	1.37	3.02	1.04	2.38	4.05	2.04	1.71	2.68	a0.33	......
Total	4.98	12.42	6.79	6.28	9.36	10.65	8.08	7.26	7.82	10.62	8.88	3.84	......
Yearly total	21.26	44.16	27.23	27.63	28.02	32.66	30.59	40.33	32.07	32.21	27.01	23.98	27.93

a Geneva record.

TABLE NO. 88.—*Record of precipitation at Perry City for the water years 1889 to 1898, inclusive.*

Month.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	a3.94	3.08	4.02	4.48	0.78	1.87	3.06	3.08	1.40	2.86	......
January	4.65	3.24	3.34	4.56	2.25	3.13	2.82	1.68	1.81	2.47	......
February	2.03	2.35	4.23	1.54	1.80	2.54	1.40	3.58	1.33	1.68	......
March	1.93	4.05	3.45	3.95	2.43	0.99	2.06	3.70	2.66	1.85	......
April	2.55	3.71	2.16	1.65	3.58	6.10	1.37	1.58	2.56	3.64	......
May	3.34	6.95	0.74	6.08	5.37	6.55	2.49	3.81	3.69	3.36	......
Total	18.44	23.38	17.94	22.26	16.21	21.18	13.20	17.43	13.45	15.86	......
June	6.49	4.55	4.13	6.65	2.13	4.05	3.54	3.67	4.18	3.47	......
July	7.07	1.67	3.54	6.86	4.99	2.86	2.72	4.18	3.55	1.82	......
August	3.04	6.97	3.90	4.12	5.21	1.38	4.67	2.54	2.30	4.68	......
Total	16.60	13.19	11.57	17.63	12.33	8.29	10.93	10.39	10.03	9.97	......
September	3.54	6.98	0.98	0.84	4.12	5.46	2.00	3.97	2.58	2.12	......
October	3.84	6.02	5.46	1.64	2.74	4.33	0.91	4.07	0.86	6.26	......
November	5.30	2.56	2.19	4.63	0.91	2.10	4.16	2.44	3.74	3.90	......
Total	12.68	15.56	8.63	7.11	7.77	11.89	7.07	10.48	7.18	12.28	......
Yearly total	47.72	52.13	38.14	47.00	36.31	41.36	31.20	38.30	30.66	38.11	40.09

a Auburn record.

TABLE NO. 89.—*Record of precipitation at Phoenix for the water years 1892 to 1898, inclusive.*

Month.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	....	4.00	3.30	3.49	4.49	0.86	3.25	....
January	....	2.49	2.31	3.37	1.52	3.83	4.50	....
February	....	3.75	2.38	3.49	5.23	1.25	1.60	....
March	....	1.80	1.89	1.01	6.26	4.52	1.83	....
April	....	3.79	1.71	1.77	0.90	2.39	3.09	....
May	....	5.28	4.50	2.42	2.59	2.50	4.14	....
Total	....	21.11	16.18	15.55	20.99	15.44	18.41	....
June	5.82	3.83	5.22	2.01	1.54	3.28	2.51	....
July	....	7.09	2.13	2.50	2.35	8.56	2.69	....
August	4.39	4.83	1.87	2.67	3.27	2.53	5.26	....
Total	....	15.75	9.22	7.27	7.16	14.37	10.46	....
September	1.54	2.32	4.47	2.28	5.15	1.49	4.20	....
October	3.33	1.62	3.92	1.11	2.46	0.90	4.54	....
November	3.88	1.83	3.91	3.83	4.27	6.26	3.80	....
Total	8.75	5.77	12.30	7.22	11.88	8.65	12.54	....
Yearly total	....	42.63	37.70	30.04	40.03	38.46	41.41	38.38

TABLE NO. 90.—*Record of precipitation at Pierpont Manor for the water years 1849 to 1871, inclusive.*

Month.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.
December	......	0.98	3.00	3.78	2.83	1.04	0.89	3.77	3.27	4.42	2.86	4.85
January	......	1.55	1.25	1.26	1.90	3.46	3.70	1.59	0.96	1.80	1.59	1.48
February	......	1.99	2.68	1.23	1.37	2.41	1.67	0.81	4.12	1.49	1.03	1.32
March	......	1.05	2.18	2.73	1.85	1.84	1.28	0.58	1.89	0.57	3.81	1.10
April	......	3.14	2.05	1.05	2.33	3.87	1.26	2.22	4.79	2.94	3.49	1.75
May	......	3.82	2.79	2.08	3.89	3.23	1.49	4.44	1.55	3.82	2.37	1.97
Total	......	12.53	13.95	12.13	14.17	15.85	10.29	13.41	16.58	15.04	15.15	12.47
June	......	1.00	2.48	2.60	1.81	3.17	4.26	2.20	3.03	2.49	4.20	2.47
July	1.73	7.76	5.11	2.73	1.31	1.06	4.48	2.41	1.11	3.92	2.31	4.03
August	2.50	1.83	1.92	1.86	2.44	1.40	2.76	2.78	4.97	3.43	5.39	3.57
Total	......	10.59	9.51	7.19	5.56	5.63	11.50	7.39	9.11	9.84	11.90	10.07
September	3.26	4.42	2.98	4.60	1.08	2.75	4.40	3.60	3.68	3.65	4.30	6.00
October	6.22	6.90	3.39	3.08	3.22	2.80	4.58	2.56	5.42	3.69	2.48	3.94
November	2.44	3.85	3.65	3.93	3.54	1.86	2.21	2.03	5.25	2.78	3.70	4.83
Total	11.92	15.17	10.02	11.61	7.84	7.41	11.19	8.19	14.35	10.12	10.48	14.77
Yearly total	......	38.29	33.48	30.93	27.57	28.89	32.98	28.99	40.04	35.00	37.53	37 31

Month.	1861.	1862.	1863.	1864.	1865.	1866.	1867.	1868.	1869.	1870.	1871.	Mean
December	2.96	1.99	3.21	3.03	4.23	2.65	4.96	1.37	3.22	3.67	4.14	......
January	2.27	2.33	2.57	2.46	2.64	2.24	1.39	4.32	2.51	4.10	2.47	......
February	2.47	2.30	2.92	1.53	0.58	2.64	3.10	1.28	3.69	3.30	1.88	......
March	3.12	3.83	2.25	2.23	4.16	2.70	1.92	3.16	2.75	2.82	3.10	......
April	3.90	1.28	2.15	3.31	3.71	2.19	4.00	1.84	2.45	1.07	2.54	......
May	3.67	2.33	3.12	5.92	2.60	3.95	7.03	2.90	3.34	1.18	1.99	......
Total	18.39	14.06	16.32	18.48	17.92	16.37	22.40	14.87	17.96	16.14	16.12	......
June	1.90	1.34	3.25	0.73	4.81	6.25	1.63	2.41	4.75	1.77	1.99	......
July	8.11	3.61	3.37	0.80	2.62	1.79	2.39	1.64	6.56	4.51	3.59	......
August	2.50	1.35	3.60	5.14	1.43	6.52	2.24	4.57	3.16	2.39	4.79	......
Total	12.51	6.30	10.22	6.67	8.86	14.56	6.26	8.62	14.47	8.67	10.37	......
September	4.07	2.68	2.99	2.74	3.27	6.46	2.79	3.64	3.95	4.52	1.76	......
October	6.20	3.26	5.85	4.29	6.15	3.66	0.96	3.14	6.23	3.00	2.18	......
November	2.44	1.85	4.57	5.76	3.21	7.30	2.14	5.65	3.62	2.74	3.06	......
Total	12.71	7.79	13.41	12.79	12.63	17.42	5.89	12.43	13.80	10.26	7.00	......
Yearly total	43.61	28.15	39.95	38.94	39.41	48.35	34.55	35.92	46.23	35.07	33.49	36.12

TABLE NO. 91.—*Record of precipitation at Plattsburg for certain water years, as indicated, from 1843 to 1898, inclusive.*

Month.	Plattsburg barracks.				Plattsburg academy.			1850.	1851.	1852.	1853.	1854.	1855.	1856.
	1843.	1844.	1845.	1846.	1847.	1848.	1849.							
December ...	*a* 1.69	0.74	1.52	1.20	*a* 1.30	2.04	2.67	3.17	7.25	1.84	2.42	0.88	2.12	3.01
January	1.26	0.84	2.84	1.13	4.10	2.75	2.30	1.10	2.19	0.90	1.00	5.84	3.32	1.25
February ...	1.46	0.54	2.67	0.74	3.56	3.69	2.59	0.98	1.99	1.33	2.89	1.98	1.23	0.30
March	2.88	2.44	2.09	1.36	7.12	3.08	3.69	0.28	2.03	2.02	3.43	3.06	1.89	1.49
April	1.48	2.61	2.02	0.62	4.09	1.58	2.76	3.78	1.61	3.92	2.68	2.28	4.41	0.96
May	4.88	5.40	1.83	2.91	0.70	2.44	3.92	7.13	3.61	*b* 2.61	4.42	1.46	0.32	3.30
Total .	13.65	12.57	12.97	7.96	20.87	15.58	17.93	16.44	18.68	12.62	16.84	15.50	13.29	10.28
June	5.48	4.41	2.15	3.11	7.19	2.39	1.64	2.58	5.35	3.49	1.33	2.96	6.80	2.62
July	5.09	4.78	2.09	......	3.75	2.89	0.95	4.12	3.09	2.44	2.42	0.96	6.79	1.58
August	5.22	6.46	1.31	......	2.76	2.07	3.60	1.38	3.22	2.55	3.10	0.39	3.13	2.06
Total ..	15.79	15.65	5.55	......	13.70	7.35	6.19	8.08	11.66	8.48	6.85	4.31	16.72	6.26
September ..	4.47	3.35	3.66	......	6.25	1.21	2.46	4.56	3.36	1.51	7.61	3.82	3.57	3.18
October	4.88	4.53	2.26	......	3.57	4.52	5.49	7.64	4.61	2.75	2.47	3.06	6.42	*b* 1.31
November ..	3.08	2.40	3.49	......	2.13	2.71	2.45	3.10	3.30	2.25	2.02	3.04	2.57	1.95
Total ..	12.43	10.28	9.41		11.95	8.44	10.40	15.30	11.27	6.51	12.10	9.92	12.56	6.44
Yearly total.	41.87	38.50	27.93	......	46.52	31.37	34.52	39.82	41.61	27.61	35.79	29.73	42.57	22.98

Month.	1857.	1858.	1859.	1860.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean
December ...	0.79	1.72	3.17	2.65	*c* 1.48	2.45	2.58	1.44	3.92	2.55	2.40	0.87	1.96	......
January	1.78	2.56	1.69	0.54	2.78	2.30	4.30	0.89	2.04	2.07	2.05	2.98	*d* 6.03	......
February ...	0.68	1.60	0.90	1.18	2.40	1.60	2.47	1.54	1.37	0.70	6.21	1.43	*e* 5.30	......
March	1.70	1.66	1.49	1.18	2.68	2.65	1.36	0.68	1.91	0.74	*f* 4.75	2.26	1.29	......
April	5.60	2.30	0.89	......	1.46	2.28	0.97	2.11	1.14	2.79	0.85	2.67	1.95	......
May	4.97	2.96	1.07	......	4.40	1.97	4.07	3.26	4.14	1.97	1.85	3.41	*e* 3.83	......
Total ..	15.52	12.80	9.21	......	15.20	13.25	15.75	9.92	14.52	10.82	18.11	13.62	20.36	......
June	5.74	2.16	1.37	......	3.35	1.49	7.62	2.42	3.52	3.85	2.80	3.90	*e* 3.32	......
July	8.26	5.25	1.10	......	4.04	3.77	5.21	3.34	2.52	2.15	5.00	7.19	*e* 2.56	......
August	4.10	2.00	2.34	......	5.82	3.55	7.18	5.76	0.89	4.50	5.95	3.93	5.82	......
Total ..	18.10	9.41	4.81	......	13.21	8.81	20.01	11.52	6.93	10.50	13.75	15.02	11.70	......
September ..	2.02	2.70	4.55	......	2.87	0.93	1.68	2.12	2.79	2.85	2.85	1.90	3.37	......
October	8.26	2.84	0.69	......	2.92	2.07	1.12	0.85	3.03	0.45	1.68	0.52	3.70	......
November ..	1.95	1.36	3.52	......	2.27	1.67	2.74	1.28	2.82	5.13	2.19	3.58	3.08	......
Total ..	12.23	6.90	8.76	......	8.06	4.67	5.54	4.25	8.64	8.43	6.72	6.00	10.15	......
Yearly total.	45.85	29.11	22.78	......	36.47	26.73	41.30	25.69	30.09	29.75	38.58	34.64	42.21	34.56

a Potsdam record.
b Lowville record.
c Burlington (Vt.) record.
d Approximate.
e Champlain Valley.
f Malone record.

TABLE No. 92.—*Record of precipitation at Pompey for certain water years, as indicated, from 1827 to 1858, inclusive.*

Month.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	1840.
December...	*a*1.96	2.60	0.07	1.88	1.97	0.25	1.09	0.70	2.30	0.97	0.23	2.16	0.55	1.08
January	4.75	1.42	0.80	0.40	......	0.30	0.49	......	2.04	6.65	0.79	0.75	2.02	1.20
February ...	2.69	1.68	0.55	......	......	2.00	0.18	......	3.05	1.25	1.03	0.64	0.45	2.64
March	1.35	1.36	0.10	0.94	......	0.05	0.18	......	2.95	0.74	0.61	0.30	1.27	1.46
April	2.20	2.18	2.26	1.70	......	1.21	1.24	......	2.06	0.86	0.91	0.57	1.53	2.53
May	1.74	2.01	1.85	3.87	......	1.96	5.28	......	2.47	4.23	1.80	2.46	3.06	3.16
Total ..	14.69	11.25	5.63	8.79	......	5.77	9.06	......	14.87	14.68	5.37	6.88	8.88	12.07
June	3.72	3.95	5.02	5.50	......	0.97	2.66	......	5.96	2.82	5.52	6.69	5.27	4.84
July	4.34	8.61	4.15	2.91	......	3.66	9.54	......	2.73	0.86	5.80	3.32	3.09	4.80
August	4.40	5.39	2.48	1.84	......	6.45	2.92	......	3.71	1.48	3.79	2.75	2.64	2.71
Total ..	12.46	17.95	11.65	10.25	......	11.08	15.12	......	12.40	5.16	15.11	12.76	11.00	12.35
September ..	3.12	3.69	4.32	3.85	......	2.69	3.26	......	2.25	1.24	2.43	1.99	3.04	2.23
October	4.92	1.57	3.12	2.32	......	2.37	3.23	......	3.26	2.27	4.29	2.52	1.10	3.22
November ..	3.31	1.54	0.70	4.76	......	3.09	0.46	......	1.82	0.87	1.17	0.67	0.99	2.11
Total ..	11.35	6.80	8.14	10.93	......	8.15	6.95	......	7.33	4.38	7.89	5.18	5.13	7.56
Yearly total.	38.50	36.00	25.42	29.97	......	25.00	31.13	......	34.60	24.22	28.37	24.82	25.01	31.98

Month.	1841.	1842.	1843.	1844.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	Mean
December...	1.89	1.59	0.71	0.56	*b*3.15	4.22	4.33	1.98	1.47	4.30	1.28	......	3.46	......
January	1.64	1.45	3.32	......	2.60	0.95	2.95	0.57	1.90	1.04	0.45	......	2.24	......
February ...	0.33	1.71	1.38	......	1.98	5.21	1.32	2.04	2.18	2.95	......	......	2.08	......
March	2.56	2.44	1.60	......	1.17	1.42	2.78	2.13	2.82	2.75	0.66	......	1.09	......
April	2.01	0.85	1.37	......	3.41	3.16	5.36	4.01	*b*5.84	3.14	2.80	......	......	......
May	1.96	3.01	2.53	......	5.42	3.44	3.68	4.61	1.30	3.65	2.45	......	......	......
Total ..	10.39	11.05	10.91	......	17.73	18.40	20.42	15.34	15.51	17.83	......	......	......	......
June	3.06	4.41	5.37	......	5.46	3.54	4.52	2.18	4.32	5.10	1.70	......	......	......
July	3.08	3.14	1.56	......	6.86	4.89	*c*2.88	2.29	1.58	2.52	......	......	......	......
August	2.23	4.70	3.04	......	2.57	4.69	2.72	6.50	1.34	*d*2.80	......	......	......	......
Total ..	8.37	12.25	9.97	......	14.89	13.12	10.12	10.97	7.22	10.42	......	......	......	......
September ..	2.01	4.49	5.71	......	5.01	2.34	1.71	4.32	4.62	*d*2.67	......		......	......
October	2.98	1.97	4.48	......	7.46	2.53	5.28	3.94	1.60	2.47	......	8.02	......	......
November .	1.83	0.96	0.46	......	4.40	3.79	5.44	3.54	2.55	1.28	......	3.40	......	......
Total ..	6.82	7.42	10.65	......	16.87	8.66	12.43	11.80	8.77	6.42	......	......	......	......
Yearly total.	25.58	30.72	31.53	......	49.49	40.18	42.97	38.11	31.50	34.67	......	......	......	32.17

a Onondaga record.
b Cazenovia record.
c Syracuse record.
d Cortland record.

Table No. 93.—*Record of precipitation at Port Ontario for certain water years, as indicated, from 1844 to 1874, inclusive.*

Month.	1844.	1845.	1846.	1849.	1850.	1851.	1852.	1853.	1854.
December	*a* 2.08	3.71	*b* 3.62	3.88	2.09	2.90	4.41	4.00	....
January	1.43	3.01	2.30	1.16	1.68	2.61	2.76	1.17	....
February	0.19	2.68	2.93	1.15	1.08	2.31	2.14	4.12	....
March	1.54	0.85	1.55	2.62	0.37	3.97	3.66	0.89	....
April	1.40	2.48	1.29	1.65	3.39	1.91	0.68	3.04	....
May	3.74	2.39	1.82	3.00	3.04	1.31	0.86	2.01	....
Total	10.38	15.12	13.51	13.46	11.65	15.01	14.51	15.32	....
June	8.32	4.73	1.38	1.66	2.03	2.55	4.06	0.72	....
July	1.42	1.58	....	0.69	6.09	2.37	1.18	....	....
August	6.50	*a* 0.38	....	1.61	1.25	1.32	0.53	....	....
Total	16.12	6.69	....	3.96	9.37	6.24	5.77	....	....
September	0.54	3.63	....	2.28	2.40	1.74	3.31	....	....
October	4.89	5.60	....	6.30	5.59	2.48	4.80	....	0.82
November	1.02	2.65	....	2.77	4.81	4.97	4.47	....	1.09
Total	6.45	11.88	....	11.33	12.80	9.19	12.58	....	....
Yearly total	32.95	33.69	....	28.75	33.82	30.44	32.86	....	....

Month.	1855.	1856.	1870.	1871.	1872.	1873.	1874.	Mean.
December	1.69	1.47	*c* 4.13	3.45	3.69	2.49	3.12	....
January	1.90	4.95	3.88	2.46	3.04	1.72	5.32	....
February	1.82	2.90	3.72	2.21	2.12	2.16	1.72	....
March	1.20	1.50	3.96	2.87	1.35	5.65	1.55	....
April	0.70	0.97	1.60	2.67	1.14	2.38	1.96	....
May	0.72	2.95	0.68	0.82	2.27	1.63	2.45	....
Total	8.03	14.74	17.97	14.48	13.61	16.03	16.12	....
June	3.60	1.70	2.16	2.00	3.72	0.95	3.28	....
July	5.20	2.16	4.34	2.38	1.75	1.95	5.42	....
August	1.65	1.41	2.54	5.83	0.64	1.56	0.09	....
Total	10.45	5.27	9.04	10.21	6.11	4.46	8.79	....
September	2.02	3.37	4.23	0.91	2.20	2.95	2.28	....
October	3.40	....	2.59	1.40	4.92	5.42	1.27	....
November	2.25	....	1.93	2.76	1.97	1.97	*d* 1.75	....
Total	7.67	....	8.75	5.07	9.09	10.34	5.30	....
Yearly total	26.15	....	35.76	29.76	28.81	30.83	30.21	31.17

a Mean of—

Mexico	2.10	0.20
Sacketts Harbor	2.06	0.57
	2)4.16	0.77
	2.08	0.38

b Mexico record.

c Mean of—

Pierpont Manor	3.67
Oswego	4.60
	2)8.27
	4.13

d Mean of—

Oswego	1.89
Sacketts Harbor	1.60
	2)3.49
	1.75

TABLE NO. 94.—*Record of precipitation at Potsdam for certain water years, as indicated, from 1828 to 1898, inclusive.*

Month.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.
December	a 2.90	2.45	2.73	2.85	1.30	0.80	0.52	0.71	0.58	0.81	1.15	0.73
January	3.50	0.59	0.63	0.60	0.60	1.25	0.35	1.43	0.36	0.74	2.66	2.70
February	2.05	1.66	0.03	0.66	1.80	0.79	0.57	1.53	1.03	1.31	0.30	0.70
March	0.51	0.65	2.56	2.90	0.58	0.86	2.32	0.47	0.40	2.80	1.04	1.20
April	1.79	2.22	0.20	2.40	1.26	1.87	2.60	2.59	0.58	1.55	1.31	0.34
May	3.44	3.20	2.72	3.64	2.31	4.30	3.22	2.58	3.53	3.49	3.73	2.08
Total	14.19	10.77	8.87	13.05	7.85	9.87	9.58	9.31	6.48	10.70	10.19	7.75
June	2.53	4.81	5.86	2.91	1.52	4.48	3.81	2.48	3.31	1.91	4.40	3.19
July	5.45	3.91	6.90	3.94	2.87	6.87	2.53	4.30	3.26	2.87	3.11	4.81
August	4.05	1 36	2.65	3.08	1.34	7.86	1.40	4.48	3.25	3.13	2.06	2.20
Total	12.03	10.08	15.41	9.93	5.73	19.21	7.74	11.26	9.82	7.91	9.57	10.20
September	4.60	2.71	3.52	4.65	2.74	4.32	2.16	2.34	0.47	3.46	2.39	3.03
October	2.72	2.09	2.58	3.08	3.62	5.28	3.56	4 70	2.37	2.87	3.08	0.83
November	2.58	1.78	3.97	1.20	2.67	0.87	1.97	2.20	0.17	3.30	1.97	0.81
Total	9.90	6.58	10.07	8.93	9.03	10.47	7.69	9.24	3.01	9.63	7.44	4.67
Yearly total	36.12	27.43	34.35	31.91	22.61	39.55	25.01	29.81	19.31	28.24	27.20	22.62

Month.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	Mean of 20 years.
December	1.09	2.72	0.46	1.69	1.81	1.80	0.59	1.30	b 3.12	2.76	......
January	1.02	0.91	1.00	2.71	3.05	2.34	1.16	......	0.55	......	......
February	1.38	0.29	1.50	1.15	0.83	2.89	0.56	......	0.28	......	......
March	2.31	0.94	2.00	3.32	1.77	1.80	0.82	......	0.42	......	......
April	3.91	1.88	1.85	2.47	1.08	3.19	0.65	......	0.39	......	......
May	2.70	3.35	2.15	1.93	3.37	3.50	3.51	......	1.77	......	......
Total	12.41	10.09	8.96	13.27	11.91	15.52	7.29	......	6.53	......	......
June	3.19	3.23	3.07	5.03	1.86	4.12	1.98	......	2.58	......	......
July	4.18	1.10	4.92	3.83	3.10	2.48	2.71	......	7.56	......	......
August	3.18	1.34	2.08	1.43	7.05	0.31	1.42	......	2.51	......	......
Total	10.55	5.67	10.07	10.29	12.01	6.91	6.11	......	12.65	......	......
September	2.95	3.82	3.07	1.75	0.96	4.84	5.13	......	3.26	......	......
October	3.32	1.44	3.33	6.11	4.65	2.76	4.65	......	3.80	......	......
November	1.62	2.01	1.87	2.60	2.15	2.20	2.12	......	0.56	......	......
Total	7.89	7.27	8.27	10.46	7.76	9.80	11.90	......	7.62	......	......
Yearly total	30.85	23.03	27.30	34.02	31.68	32.23	25.30	......	26.80	......	28.77

a Lowville record.

b Mean of—
Gouverneur 3.24
Lowville 3.01
2)6.25
3.12

TABLE NO. 94.—*Record of precipitation at Potsdam for certain water years, as indicated, from 1828 to 1898, inclusive*—Continued.

Month.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean of 9 years.	Mean of 29 years.
December	*a*2.68	3.75	2.00	2.28	1.28	4.89	2.55	2.69	0.83	3.28	......	......
January	3.42	2.75	3.18	*b*2.84	1.07	2.16	4.50	1.80	2.70	......	......	......
February	4.66	6.42	3.62	2.98	2.99	1.70	2.40	4.66	2.80	......	......	......
March	1.48	4.40	3.78	3.22	0.75	1.72	1.88	3.81	2.70	......	......	......
April	4.18	1.88	3.13	1.02	3.07	0.67	1.17	37	2.18	......	......	......
May	3.38	5.08	0.79	5.01	5.38	3.49	2.60	46	3.30	......	......	......
Total	19.78	24.28	16.50	17.33	14.52	14.63	15.10	15.79	14.51	......	......	......
June	7.35	4.27	2.01	*b*6.93	5.00	3.68	2.59	2.76	2.70	......	......	......
July	7.87	3.39	5.68	*b*4.53	2.58	*b*3.40	3.34	3.13	7.04	......	......	......
August	4.75	4.33	6.77	6.93	9.92	*b*0.95	6.72	3.31	1.99	......	......	......
Total	19.97	11.99	14.46	18.39	17.50	8.01	12.65	9.20	11.73	......	......	......
September	3.05	4.41	1.43	3.11	3.00	3.34	1.68	5.10	1.31	......	......	......
October	4.42	2.33	2.67	1.78	1.02	3.67	0.73	1.14	0.55	......	......	......
November	4.10	3.76	2.92	4.07	2.05	1.78	1.67	2.02	4.19	......	......	......
Total	11.57	10.50	7.02	8.98	6.07	8.79	4.08	8.26	6.05	......	......	......
Yearly total	51.32	46.77	37.98	44.68	38.09	31.43	31.83	33.25	32.29	......	38.63	31.83

a Mean of—

Utica	3.12
Palermo	2.25
	2)5.37
	2.68

b Mean of—

North Hammond	2.58	8.25	4.21	3.88	1.08
DeKalb Junction	3.08	5.72	5.40	3.41	0.91
Canton	2.87	6.81	3.98	2.92	0.85
	3)8.53	20.78	13.59	10.21	2.84
	2.84	6.93	4.53	3.40	0.95

TABLE NO. 95.—*Record of precipitation at Poughkeepsie for certain water years, as indicated, from 1830 to 1898, inclusive.*

Month.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1841.	1842.	1843.	1844.	1845.	1846.
December	*a*2.00	5.85	1.27	3.46	2.04	*a*3.56	2.78	4.50	*a*2.92	2.51	2.60	0.95	3.86	2.65
January	2.46	2.50	4.88	2.62	......	3.55	6.14	......	4.87	1.37	2.13	3.93	4.45	2.20
February	2.13	3.50	3.22	1.53	......	1.28	2.02	......	0.75	3.00	1.05	1.15	2.46	1.41
March	4.85	3.50	4.12	2.13	......	2.74	0.87	......	1.73	2.71	3.08	4.23	3.54	2.83
April	2.07	5.85	3.20	1.75	......	5.03	2.28	......	3.64	4.25	2.92	1.05	2.58	1.57
May	5.32	3.40	3.27	4.08	......	1.66	1.26	......	1.47	2.62	1.37	5.05	1.14	5.16
Total	18.83	24.60	19.96	15.57	......	17.82	15.95	......	15.38	16.46	13.15	16.36	18.03	15.82
June	4.24	4.22	0.82	4.62	......	2.91	4.73	......	3.03	3.98	4.78	4.55	2.10	2.16
July	5.85	3.81	4.98	3.26	......	2.89	4.31	......	0.94	5.60	2.45	8.45	2.36	4.20
August	1.50	8.67	8.26	4.45	......	1.47	1.54	......	4.15	4.13	8.25	2.45	2.76	4.09
Total	11.59	16.70	14.06	12.33	......	7.27	10.58	......	8.12	13.71	15.48	15.45	7.22	10.45
September	1.46	4.48	3.80	2.52	......	0.89	1.49	......	1.47	3.75	4.62	2.45	3.00	0.20
October	3.61	6.08	3.73	8.64	......	1.59	2.67	......	2.07	1.05	8.20	4.53	2.26	2.41
November	7.00	2.45	3.65	2.88	......	2.19	2.07	......	3.02	3.05	3.50	1.51	5.15	6.67
Total	12.07	13.01	11.18	14.04	......	4.67	6.23	......	6.56	7.85	16.32	8.49	10.41	9.28
Yearly total	42.49	54.31	45.20	41.94	......	29.76	32.76	......	30.06	38.02	44.95	40.30	35.66	35.55

Table No. 95.—*Record of precipitation at Poughkeepsie for certain water years, as indicated, from 1830 to 1898, inclusive*—Continued.

Month.	1847.	1848.	1849.	1850.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean
December	3.11	6.46	[a]4.72	1.91	[b]4.41	4.00	3.66	1.21	3.59	4.12	2.92	1.67	4.57	......
January	3.30	......	0.45	......	2.63	6.65	5.40	2.35	2.38	3.39	0.88	1.62	5.27	......
February	3.50	......	1.42	......	3.32	4.45	1.44	6.78	3.05	0.90	5.98	2.66	3.22	......
March	2.10	......	2.71	......	5.51	2.91	2.85	3.12	1.21	1.71	6.20	3.00	2.43	......
April	0.92	......	0.96	......	1.57	2.16	0.61	2.98	1.32	3.54	1.11	1.30	2.96	......
May	3.22	......	6.36	......	4.80	1.66	6.05	7.06	5.12	1.99	2.50	3.36	4.74	......
Total	16.15	......	16.62	......	22.24	21.83	20.01	23.50	16.67	15.65	19.59	13.61	23.19	......
June	3.67	......	1.24	......	2.45	2.14	3.05	1.49	1.71	1.53	2.71	4.25	1.53	......
July	1.92	......	0.49	......	5.08	5.24	4.19	1.66	2.81	2.24	3.33	9.37	3.20	......
August	2.35	......	3.39	......	5.71	4.12	[c]6.28	4.11	1.04	3.49	2.28	2.81	8.85	......
Total	7.94	......	5.12	......	13.24	11.50	13.52	7.26	5.56	7.26	8.32	16.43	13.58	......
September	3.23	......	0.83	......	4.57	1.13	1.37	3.43	4.52	1.34	5.70	1.83	2.21	......
October	1.92	......	5.58	......	4.34	1.81	0.89	2.75	5.99	4.42	2.66	0.13	3.18	......
November	0.89	......	3.33	......	0.80	2.11	5.96	1.83	2.89	2.86	1.45	5.45	4.78	......
Total	6.04	......	9.74	......	9.71	5.05	8.22	8.01	13.40	8.62	9.81	7.41	10.17	......
Yearly total	30.13	......	31.48	......	45.19	38.38	41.75	38.77	35.63	31.53	37.72	37.45	46.94	38.52

[a] Kingston record. [b] Rondout record. [c] Mean of Hudson Valley.

Table No. 96.—*Record of precipitation at Prattsburg for certain water years, as indicated, from 1829 to 1845, inclusive.*

Month.	1829.	1830.	1831.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	Mean.
December	[a]1.05	1.27	3.47	[b]1.68	2.50	3.35	5.70	3.50	1.35	1.00	......
January	2.10	1.73	......	3.09	2.10	2.60	1.35	1.10	1.26	2.35	......
February	1.05	0.78	......	1.68	2.20	1.10	1.80	3.75	1.17	2.85	......
March	1.42	2.67	......	1.55	3.30	3.05	5.50	1.50	1.00	1.75	......
April	1.39	1.96	......	2.00	3.35	4.10	3.75	3.25	0.95	3.00	......
May	2.74	4.44	......	4.90	4.00	0.95	2.75	1.30	4.50	2.75	......
Total	9.75	12.85	......	14.90	17.45	15.15	20.85	14.40	10.23	13.70	......
June	3.61	7.60	......	5.87	4.80	2.30	3.70	4.70	1.40	2.40	......
July	3.91	3.08	......	3.55	3.85	1.50	3.10	2.65	8.12	0.15	......
August	2.20	2.57	......	3.30	3.24	2.20	3.50	1.73	2.25	1.60	......
Total	9.72	13.25	......	12.72	11.89	6.00	10.30	9.08	11.77	4.15	......
September	2.56	2.23	......	0.14	1.50	2.33	6.00	7.85	3.10	3.50	......
October	1.55	1.70	......	0.75	4.40	1.78	3.05	4.30	2.60	5.22	......
November	2.36	3.92	......	1.90	2.85	2.45	2.35	2.50	1.70	1.65	......
Total	6.47	7.85	......	2.79	8.75	6.56	11.40	14.65	7.40	10.37	......
Yearly total	25.94	33.95	......	30.41	38.09	27.71	42.55	38.13	29.40	28.22	32.71

[a] Auburn record. [b] Canandaigua record.

Table No. 97.—*Record of precipitation at Rochester for certain water years, as indicated, from 1830 to 1898, inclusive.*

Month.	1830.	1834.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.
December	*a* 2.17	*a* 3.86	0.53	0.46	1.58	2.62	1.06	1.18	1.93	2.53	2.80	1.90
January	1.68	0.11	1.15	2.40	0.16	1.70	2.40	1.16	2.13	1.13	2.79	2.21
February	0.22	0.73	0.81	0.59	2.50	1.70	2.05	1.37	0.21	2.12	2.62	0.37
March	3.42	0.78	0.60	0.55	3.00	1.24	1.35	1.40	3.55	2.89	2.09	1.14
April	1.32	1.60	4.46	1.70	0.50	2.14	2.48	2.22	3.27	2.48	2.22	0.72
May	3.51	0.91	0.79	6.12	2.82	4.91	4.90	4.13	1.17	2.18	1.83	4.18
Total	12.32	7.99	8.34	11.82	10.56	14.31	14.24	11.46	12.26	13.33	14.35	10.52
June	8.35	1.61	5.49	2.77	2.58	1.33	3.40	2.63	1.29	3.66	2.93	3.19
July	1.99	1.45	1.83	2.74	1.11	3.04	4.20	3.11	4.58	3.69	2.12	3.30
August	1.91	1.38	3.57	1.29	3.72	2.59	3.56	4.09	1.60	1.42	0.70	1.74
Total	12.25	4.44	10.89	6.80	7.41	6.96	11.16	9.83	7.47	8.77	5.75	8.23
September	3.93	1.89	2.63	2.30	2.34	0.87	1.19	2.81	6.14	5.19	5.52	0.68
October	1.04	4.06	4.56	2.66	5.10	3.20	0.56	2.83	1.21	2.20	4.42	4.81
November	4.70	1.99	2.25	3.25	4.16	1.68	2.82	1.71	4.65	3.43	1.07	2.19
Total	9.67	7.94	9.44	8.21	11.60	5.75	4.57	7.35	12.00	10.82	11.01	7.68
Yearly total	34.24	20.37	28.67	26.83	29.57	27.02	29.97	28.64	31.73	32.92	31.11	26.43

Month.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.
December	1.64	1.42	2.52	1.31	4.11	2.31	5.28	2.70	2.50	1.72	3.25
January	3.51	2.18	3.01	2.25	1.39	3.03	1.36	1.57	2.47	1.81	3.33
February	2.01	2.92	3.71	1.04	1.29	1.95	2.00	2.08	2.86	2.86	1.46
March	2.62	1.53	0.92	1.77	2.35	1.70	1.38	3.21	2.30	1.07	1.48
April	2.49	1.18	2.65	0.78	1.44	2.56	1.16	4.32	3.24	3.54	2.04
May	2.65	2.34	1.73	4.48	3.81	2.87	2.21	2.08	4.56	2.14	1.96
Total	14.92	11.57	14.54	11.63	14.39	14.42	13.39	15.96	17.93	13.14	13.52
June	4.48	4.96	2.65	2.13	4.33	1.84	*b* 2.61	4.39	1.48	5.47	5.55
July	2.75	2.49	2.05	6.16	0.94	5.97	3.58	4.09	1.00	0.25	5.26
August	2.77	3.85	5.27	2.78	3.62	1.93	1.54	1.33	2.01	0.90	2.63
Total	10.00	11.30	9.97	11.07	8.89	9.74	7.73	9.81	4.49	6.62	13.44
September	4.32	2.76	4.25	2.96	3.91	2.95	1.06	2.97	6.83	5.18	1.80
October	2.84	6.79	4.94	1.77	4.17	5.06	2.14	3.89	2.57	1.64	4.84
November	2.58	3.61	3.65	1.80	3.31	3.35	3.92	2.86	2.34	1.48	1.06
Total	9.74	13.16	12.84	6.53	11.39	11.36	7.12	9.72	11.74	8.30	7.70
Yearly total	34.66	36.03	37.35	29.23	34.67	35.52	28.24	35.49	34.16	28.06	34.66

Month.	1856.	1857.	1858.	1859.	1860.	1861.	1862.	1863.	1864.	1865.	1866.
December	2.48	2.68	4.37	3.48	4.46	1.53	1.38	2.34	2.63	4.82	1.75
January	1.94	1.92	1.58	1.37	1.08	2.48	3.51	2.23	2.91	2.83	1.48
February	0.77	3.52	2.38	1.07	1.35	2.98	2.82	2.44	1.18	1.74	2.39
March	1.92	1.99	1.46	2.49	1.64	1.55	5.15	3.49	3.44	3.17	2.71
April	2.32	5.67	2.85	4.03	1.80	3.24	2.13	2.79	3.23	3.03	3.20
May	2.48	3.72	3.40	2.71	1.41	3.88	2.05	1.83	6.54	3.30	2.90
Total	11.91	19.50	16.04	15.15	11.74	15.66	17.04	15.12	19.93	18.89	14.43
June	1.90	5.19	3.40	1.17	3.78	1.37	4.44	1.37	1.57	5.43	3.90
July	1.80	3.58	4.66	4.16	4.50	5.11	4.13	5.03	1.66	1.47	1.36
August	2.70	2.74	3.28	5.14	2.50	2.22	3.70	5.49	5.49	1.04	4.91
Total	6.40	11.51	11.34	10.47	10.78	8.98	10.79	10.10	8.72	7.94	10.17
September	3.52	1.90	3.19	2.86	3.52	6.09	2.36	1.51	1.83	4.33	4.11
October	1.00	4.22	0.86	1.21	4.71	2.81	3.98	2.72	5.51	4.29	1.22
November	1.32	3.96	5.70	1.92	3.36	1.41	2.46	2.97	2.66	1.70	3.29
Total	5.84	10.08	9.75	5.99	11.59	10.31	8.80	7.20	10.00	10.32	8.62
Yearly total	24.15	41.09	37.13	31.61	34.11	34.95	36.63	32.42	38.65	37.15	33.22

a Canandaigua record.

b Geneva record.

TABLE No. 97.—*Record of precipitation at Rochester for certain water years, as indicated, from 1830 to 1898, inclusive*—Continued.

Month.	1867.	1868.	1869.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.
December	3.22	*a* 0.70	3.23	3.38	*b* 3.26	1.86	4.05	4.59	1.01	2.91	1.72
January	2.68	1.45	1.35	3.40	1.93	2.40	3.33	5.72	1.19	4.27	3.10
February	3.01	1.59	4.18	3.38	3.25	1.28	1.52	3.35	1.21	5.40	0.46
March	2.08	4.38	2.27	4.66	3.82	2.50	7.02	2.90	1.92	3.89	3.55
April	2.93	1.86	1.47	2.75	3.59	2.15	4.71	4.99	1.99	1.99	2.67
May	5.69	6.36	2.56	0.78	1.68	2.18	3.52	2.98	2.76	1.55	1.20
Total	19.61	16.34	15.01	18.35	17.53	12.37	24.15	24.53	10.08	20.01	12.70
June	1.40	2.87	6.62	......	4.60	5.35	1.84	2.79	3.33	3.33	3.16
July	3.54	0.68	4.90	4.72	3.49	2.56	5.42	4.37	2.12	4.49	4.42
August	0.72	3.22	4.60	......	6.05	1.89	3.01	0.84	5.08	0.36	2.98
Total	5.66	6.77	16.12	......	14.14	9.80	10.27	8.00	10.53	8.18	10.56
September	2.28	7.51	5.11	5.01	0.51	1.72	2.97	2.73	2.87	5.69	2.31
October	1.92	1.67	2.83	......	2.55	8.14	8.62	2.17	2.41	1.26	3.06
November	*a*0.33	4.42	3.58	......	3.10	2.07	3.24	1.97	2.14	1.77	5.46
Total	4.53	13.60	11.52	......	6.16	11.93	14.83	6.87	7.42	8.72	10.83
Yearly total	29.80	36.71	42.65	......	37.83	34.10	49.25	30.40	28.03	36.91	34.09

Month.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
December	1.75	6.17	3.26	2.99	4.11	2.10	2.33	2.62	2.25	1.89	1.58
January	8.08	3.53	2.07	4.68	2.04	0.94	5.13	2.12	2.58	1.34	1.87
February	4.84	3.27	3.82	2.86	1.25	2.28	1.94	1.54	2.18	4.75	0.85
March	4.89	2.53	2.57	5.33	1.74	1.65	3.30	0.96	2.85	0.94	2.34
April	3.71	1.44	2.12	1.15	2.18	1.61	0.94	2.96	4.05	2.51	1.22
May	2.25	1.35	5.54	5.86	5.57	0.53	2.28	2.02	2.98	1.17	1.79
Total	25.52	18.29	19.38	22.87	16.89	9.11	15.92	12.22	16.89	12.60	9.65
June	1.69	3.73	2.45	3.20	2.50	......	4.32	4.27	2.33	1.51	4.69
July	3.72	4.61	3.49	2.20	1.17	......	3.03	2.74	1.07	1.90	1.12
August	3.24	3.47	5.53	1.44	2.73	......	2.52	2.20	7.26	1.59	3.61
Total	8.65	11.81	11.47	6.84	6.40	......	9.87	9.21	10.66	5.00	9.42
September	1.35	2.80	2.72	1.82	0.82	......	1.90	2.49	2.90	0.90	2.19
October	3.83	0.67	5.31	3.63	0.62	......	1.87	2.66	2.30	1.31	3.22
November	5.07	4.47	3.19	1.96	2.01	2.03	1.32	2.10	4.45	0.80	2.86
Total	10.25	7.94	11.22	7.41	3.45	......	5.09	7.25	9.65	3.01	8.27
Yearly total	44.42	38.04	42.07	37.12	26.74	......	30.88	28.68	37.20	20.61	27.34

Month.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	2.00	2.57	2.97	3.85	1.77	3.84	3.50	3.77	2.21	3.39	......
January	3.33	4.83	3.75	2.73	1.50	3.27	3.12	3.38	2.47	5.24	......
February	2.41	3.59	4.17	2.77	3.31	3.41	2.50	5.37	2.31	3.08	......
March	1.78	2.99	4.44	2.44	1.81	1.84	1.56	6.32	3.14	2.34	......
April	2.84	2.17	1.89	1.12	3.97	2.03	2.04	1.09	1.63	1.72	......
May	2.36	6.00	1.12	4.84	5.69	6.87	3.44	1.64	1.33	2.94	......
Total	14.72	22.15	18.34	17.75	18.05	21.26	16.16	21.57	13.09	18.71	......
June	5.36	2.66	1.56	6.68	0.94	3.43	1.56	2.80	2.92	0.89	......
July	3.08	1.62	3.62	3.21	2.81	2.92	1.88	4.75	6.37	2.03	......
August	1.12	2.31	3.01	3.52	5.61	0.70	3.40	2.71	1.72	5.05	......
Total	9.56	6.59	8.19	13.41	9.36	7.05	6.84	10.26	11.01	7.97	......
September	2.21	5.13	1.41	1.55	2.26	2.03	2.38	3.50	0.46	3.36	......
October	4.02	4.77	2.36	0.78	1.83	2.86	1.38	0.58	0.97	4.30	......
November	4.62	4.05	2.46	3.61	1.93	1.65	3.39	2.49	3.71	3.54	......
Total	10.85	13.95	6.23	5.94	6.02	7.14	7.15	6.57	5.14	11.20	......
Yearly total	35.13	42.69	32.76	37.10	33.43	35.45	30.15	38.40	29.24	37.88	33.61

a Geneva record. *b* Lockport record.

TABLE No. 98.—*Record of precipitation at Rome for certain water years, as indicated, from 1889 to 1898, inclusive.*

Month.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	......	4.65	4.03	5.77	[a] 1.98	5.43	2.75	4.15	2.52	3.49	......
January	......	5.68	5.18	4.81	2.00	3.77	1.89	2.17	3.10	5.44	......
February	......	4.77	5.99	2.77	7.03	[b] 2.80	2.88	7.59	1.69	2.38	......
March	......	4.00	3.74	7.36	3.16	[b] 1.93	0.89	4.74	4.90	3.45	......
April	......	4.03	......	1.69	3.97	2.39	2.55	1.25	3.36	4.19	......
May	......	7.00	......	6.11	6.47	5.01	2.61	2.85	4.12	3.82	......
Total	......	30.03	......	28.51	24.61	21.33	13.57	22.75	19.69	22.77	......
June	6.25	6.59	......	5.02	1.79	5.98	2.05	1.51	4.87	3.76	......
July	6.56	3.21	......	4.62	2.96	2.01	3.35	6.04	4.92	4.18	......
August	1.67	5.70	......	7.04	6.68	2.40	3.49	1.92	2.71	10.98	......
Total	14.48	15.50	......	16.68	11.43	10.39	8.89	9.47	12.50	18.92	......
September	3.97	8.61	......	3.34	3.54	6.07	2.51	4.57	2.30	3.95	......
October	3.12	7.26	3.34	[a] 2.59	2.56	4.65	2.01	1.90	0.38	3.80	......
November	5.35	5.96	5.54	3.70	2.10	1.78	4.32	5.06	6.25	[c] 3.79	......
Total	12.44	21.83	......	9.63	8.20	12.50	8.84	11.53	8.93	11.54	......
Yearly total	......	67.36	......	54.82	44.24	44.22	31.30	43.75	41.12	53.23	47.50

[a] Utica record.

[b] Mean of—

Eastern Plateau	2.73	1.61
Northern Plateau	2.87	2.26
	2)5.60	3.87
	2.80	1.93

[c] Mean of—

Little Falls	3.10
Canajoharie	3.99
St. Johnsville	4.29
	3)11.38
	3.79

TABLE No. 99.—*Record of precipitation at Romulus for the water years 1891 to 1898, inclusive.*

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	......	3.48	0.61	1.89	2.73	3.11	2.08	2.01	......
January	2.74	3.03	1.10	1.94	1.81	2.34	0.97	4.05	......
February	2.12	1.98	2.49	2.64	0.56	3.66	0.93	1.81	......
March	......	3.42	1.90	0.58	1.00	4.47	3.80	1.90	......
April	......	1.11	3.02	4.57	1.37	2.90	2.53	3.60	......
May	......	5.04	6.11	6.02	3.40	4.50	4.80	4.31	......
Total	......	18.06	15.23	17.64	10.87	20.98	15.11	17.68	......
June	......	3.89	1.41	2.93	3.32	2.43	2.71	3.42	......
July	......	2.83	2.20	2.90	3.20	4.92	4.14	2.42	......
August	......	6.06	4.15	2.34	3.90	3.17	0.78	4.97	......
Total	......	12.78	7.76	8.17	10.42	10.52	7.63	10.81	......
September	......	1.12	3.26	4.92	1.52	5.10	3.95	2.03	......
October	4.07	1.34	1.65	3.92	1.15	3.30	1.21	8.09	......
November	1.25	3.21	0.56	1.44	3.80	2.92	4.06	4.48	......
Total	......	5.67	5.47	10.28	6.47	11.32	9.22	14.60	......
Yearly total	......	36.51	28.46	36.09	27.76	42.82	31.96	43.09	35.24

Table No. 100.—*Record of precipitation at Rondout for the water years 1889 to 1894, inclusive.*

Month.	1889.	1890.	1891.	1892.	1893.	1894.	Mean.
December	*a*3.35	4.41	4.00	3.43	1.07	3.20	....
January	4.60	2.10	11.38	5.27	5.63	....	....
February	1.98	3.76	4.11	1.66	8.71	....	....
March	0.87	5.77	5.18	3.58	4.60	1.70	....
April	2.17	1.62	2.40	0.72	4.20	3.00	....
May	3.30	6.51	1.68	5.39	7.78	4.01	....
Total	16.27	24.17	28.75	20.05	31.99	....	....
June	5.48	1.96	3.92	4.66	2.91	....	....
July	9.05	1.84	6.43	3.80	2.12	....	....
August	2.83	9.46	4.17	8.34	5.50	....	....
Total	17.36	13.26	14.52	16.80	10.53	....	....
September	4.24	4.26	1.77	2.06	4.22	....	....
October	4.12	5.28	3.63	0.89	3.32	....	....
November	6.07	0.67	3.10	5.57	2.20	....	....
Total	14.43	10.21	8.50	8.52	9.74	....	....
Yearly total	48.06	47.64	51.77	45.37	52.26	....	49.02

a Albany record.

Table No. 101.—*Record of precipitation at Rutland for the water years 1846 to 1861, inclusive.*

Month.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.
December	*a* 1.27	1.84	3.67	3.57	2.79	3.69	3.67	5.51	1.28
January	2.72	3.13	1.84	2.07	2.50	1.71	1.68	1.00	2.64
February	1.30	2.18	0.87	0.70	2.96	2.94	1.42	8.52	2.72
March	1.80	1.52	2.61	3.41	1.45	2.46	2.74	3.45	2.21
April	1.58	2.70	1.69	1.75	2.20	1.46	1.79	2.76	4.07
May	2.94	0.63	3.01	4.30	3.65	2.91	2.62	3.59	2.25
Total	11.61	12.00	13.69	15.80	15.55	15.17	13.92	19.83	15.17
June	4.25	4.14	1.33	1.38	1.73	2.82	2.11	1.18	2.82
July	4.60	6.12	4.49	2.79	7.63	8.03	3.59	1.60	0.67
August	2.53	1.36	1.87	1.88	3.51	3.46	1.13	2.70	0.92
Total	11.38	11.62	7.69	6.05	12.87	14.31	6.83	5.48	4.41
September	3.68	8.06	3.18	4.62	4.23	2.17	3.78	5.50	2.65
October	6.68	4.32	4.20	7.06	6.82	3.04	2.95	3.12	3.87
November	5.15	4.54	2.55	3.44	3.88	4.90	3.88	3.42	3.40
Total	15.51	16.92	9.93	15.12	14.93	10.11	10.61	12.04	9.92
Yearly total	38.50	46.54	31.31	36.97	43.35	39.59	31.36	37.35	29.50

Month.	1855.	1856.	1857.	1858.	1859.	1860.	1861.	Mean.
December	1.74	3.49	2.17	4.97	2.31	3.80	2.24	....
January	2.91	1.93	1.00	1.83	1.68	1.87	2.61	....
February	1.62	0.76	3.57	1.39	1.20	0.97	3.27	....
March	0.80	0.76	2.15	0.97	3.40	1.31	3.27	....
April	1.93	2.02	5.16	3.16	3.87	1.67	3.27	....
May	0.93	4.47	2.90	3.54	1.73	1.57	3.52	....
Total	9.93	13.43	16.95	15.86	14.19	11.19	18.18	....
June	4.82	2.12	5.64	2.76	3.50	4.45	2.09	....
July	3.93	2.80	2.46	3.14	1.43	4.56	8.26	....
August	2.73	3.28	4.45	2.91	5.75	3.55	2.47	....
Total	11.48	8.20	12.55	8.81	10.68	12.56	12.82	....
September	3.57	3.49	3.73	4.11	3.20	5.21	4.12	....
October	5.27	1.45	5.78	2.25	2.16	5.00	7.27	....
November	1.82	2.26	4.80	1.90	4.53	5.10	2.26	....
Total	10.66	7.20	14.31	8.26	9.89	15.31	13.65	....
Yearly total	32.07	28.83	43.81	32.93	34.76	39.06	44.65	36.54

a Sacketts Harbor record.

TABLE NO. 102.—*Record of precipitation at Sacketts Harbor for certain water years, as indicated, from 1841 to 1898, inclusive.*

Month.	1841.	1842.	1843.	1844.	1845.	1846.	1849.	1850.	1851.	1852.	1859.	1860.	1861.
December	2.85	3.11	1.96	2.06	1.70	1.27	......	4.85	6.26	4.25	......	5.18	2.96
January	3.18	0.94	2.35	2.74	3.50	2.61	......	3.16	2.39	2.90	......	2.40	2.64
February	0.51	1.93	1.85	0.85	2.92	2.24	......	3.55	4.52	2.79	......	1.52	5.44
March	3.00	3.24	2.57	1.91	2.55	2.28	......	2.13	4.33	5.89	......	1.39	3.08
April	2.73	3.16	2.15	1.79	2.04	1.96	......	2.87	3.95	3.29	......	1.51	2.70
May	1.74	1.76	1.44	3.37	4.16	3.49	1.89	6.15	5.08	......	......	1.63	4.48
Total	14.01	14.14	12.32	12.72	16.87	13.85	......	22.71	26.53	......	......	13.63	21.30
June	1.58	4.43	4.70	3.74	1.85	1.98	2.07	1.64	2.78	......	......	2.36	2.10
July	4.14	3.81	2.79	3.78	5.45	......	0.91	7.57	7.67	......	1.62	4.79	6.32
August	1.59	3.38	1.85	3.80	0.57	......	4.06	3.12	3.53	......	3.28	2.98	4.04
Total	7.31	11.62	9.34	11.32	7.87	......	7.04	12.33	13.98	......	......	10.13	12.46
September	5.36	4.21	2.66	0.41	3.18	......	6.51	4.75	3.35	......	2.64	3.70	5.80
October	1.58	4.11	6.91	3.52	2.64	......	5.21	12.39	6.09	......	1.04	3.64	4.62
November	3.85	4.38	2.44	1.62	2.24	......	4.99	3.93	5.85	......	4.74	5.92	3.38
Total	10.79	12.70	12.01	5.55	8.06	......	16.71	21.07	15.29	......	8.42	13.26	13.80
Yearly total	32.11	38.46	33.67	29.59	32.80	......	......	56.11	55.80	......	......	37.02	47.56

Month.	1862.	1863.	1864.	1865.	1866.	1867.	1870.	1871.	1872.	1873.	1874.	1875.
December	1.30	1.27	4.50	3.38	2.30	2.46	[a]4.02	1.60	1.98	1.39	1.05	0.35
January	1.13	2.26	2.56	1.58	1.26	......	2.98	1.60	2.00	1.90	4.71	1.50
February	1.46	3.08	1.78	1.22	2.70	......	2.30	1.05	2.00	0.30	2.24	1.33
March	4.20	2.05	2.72	3.94	2.82	......	1.34	2.32	1.50	5.60	2.07	1.12
April	2.14	3.34	4.80	3.30	2.88	......	0.42	2.15	1.60	2.72	0.97	1.01
May	2.42	2.42	6.76	2.59	3.22	......	1.68	1.58	2.14	0.92	0.92	3.32
Total	12.65	14.42	23.12	16.01	15.18	......	12.74	10.30	11.22	12.83	11.96	8.63
June	1.68	2.34	1.14	4.08	3.84	......	1.48	1.38	2.90	2.30	1.84	1.55
July	3.60	2.56	1.14	2.28	1.50	......	1.46	2.17	1.55	1.96	3.31	1.83
August	1.64	3.44	3.02	0.56	5.88	......	1.61	6.14	3.64	2.70	1.10	2.64
Total	6.92	8.34	5.30	6.92	11.22	......	4.55	9.69	8.09	6.96	6.25	6.02
September	2.96	2.40	2.94	1.73	5.34	......	4.55	1.40	3.85	2.20	3.20	3.01
October	3.72	5.44	5.94	4.78	2.90	......	2.05	1.55	5.20	5.25	4.57	2.99
November	2.54	4.70	5.36	2.26	4.12	......	1.27	3.68	2.39	1.55	1.60	1.65
Total	9.22	12.54	14.24	8.77	12.36	......	7.87	6.63	11.44	9.00	9.37	7.65
Yearly total	28.79	35.30	42.66	31.70	38.76	......	25.16	26.62	30.75	28.79	27.58	22.30

Month.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.
December	1.21	1.51	[b]1.98	6.28	1.51	2.96	2.90	1.57	2.43	2.68	3.18	1.88
January	1.42	......	2.35	0.92	2.02	2.99	1.40	2.72	2.36	2.20	2.62	2.86
February	3.60	......	1.42	1.42	1.33	1.34	1.94	1.78	2.37	1.42	2.12	1.50
March	3.91	......	2.47	1.95	1.88	2.59	2.72	1.00	2.45	0.92	2.72	1.34
April	0.55	1.79	2.68	0.60	0.92	0.42	1.26	1.56	0.54	1.48	1.84	1.96
May	1.35	0.75	1.95	0.90	1.09	2.97	4.97	3.70	3.25	1.42	2.16	1.56
Total	12.04	......	12.85	12.07	8.75	13.27	15.19	12.33	13.40	10.12	14.64	11.10
June	1.80	2.21	1.01	3.47	0.88	2.54	2.88	2.06	0.99	2.49	1.08	2.08
July	2.83	2.97	4.58	1.15	2.00	0.38	1.68	3.93	3.98	2.42	2.38	0.53
August	0.78	......	5.30	2.30	1.62	0.47	2.80	2.10	2.69	2.29	3.92	1.49
Total	5.41	......	10.89	6.92	4.50	3.39	7.36	8.09	7.66	7.20	7.38	4.10
September	3.00	1.86	1.43	1.80	2.80	1.21	1.95	2.83	2.69	3.28	4.38	1.12
October	3.00	1.50	4.47	0.92	3.31	2.94	0.92	2.35	2.63	3.69	1.44	5.38
November	1.97	4.43	4.91	5.32	3.14	2.03	1.28	1.87	2.49	[c]2.54	3.00	1.46
Total	7.97	7.79	10.81	8.04	9.25	6.18	4.15	7.05	7.81	9.51	8.82	7.96
Yearly total	25.42	......	34.55	27.03	22.50	22.84	26.70	27.47	28.87	26.83	30.84	23.16

[a] Mean of—

Depauville	4.38
Pierpont Manor	3.67
	2)8.05
	4.02

[b] Mean of—

North Volney	1.90
Oswego	2.34
Adams	1.70
	3)5.94
	1.98

[c] Mean of—

North Volney	2.95
Oswego	2.17
Palermo	2.50
	3)7.62
	2.54

Table No. 102.—*Record of precipitation at Sacketts Harbor for certain water years, as indicated, from 1841 to 1898, inclusive*—**Continued.**

Month.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	1.62	a 2.68	5.80	2.52	3.47	1.42	3.52	2.27	2.96	1.61	3.68	......
January	0.20	2.42	3.19	2.61	2.78	2.79	3.16	3.96	1.05	1.29	2.64	......
February	0.58	1.18	3.09	2.05	1.75	2.35	2.62	1.10	5.30	1.79	2.08	......
March	0.90	0.70	3.02	2.89	2.16	1.22	2.17	2.16	1.96	2.41	0.65	......
April	0.66	4.90	1.52	0.85	0.64	3.98	1.52	1.53	0.38	1.16	1.17	......
May	0.28	8.25	3.37	1.03	4.81	5.59	4.96	2.66	2.41	3.99	b3.41	......
Total	4.24	20.13	19.99	11.95	15.61	17.35	17.95	13.68	14.06	12.25	13.63	......
June	1.09	11.50	2.35	1.94	5.41	1.66	3.02	1.77	1.54	1.03	2.50	......
July	2.24	3.91	1.43	3.21	4.52	2.26	2.02	2.93	4.02	2.55	0.60	......
August	2.59	0.89	0.80	2.00	6.52	9.00	0.53	3.05	3.70	1.90	2.65	......
Total	5.92	16.30	4.58	7.15	16.45	12.92	5.57	7.75	9.26	5.48	5.75	......
September	4.49	3.08	6.27	1.86	4.80	2.28	4.22	2.07	5.84	0.79	1.35	......
October	7.13	3.08	3.16	3.43	2.00	1.74	4.71	1.77	2.24	0.80	2.75	......
November	2.97	10.02	1.42	3.78	3.90	2.74	2.01	4.12	2.96	2.66	b3.02	......
Total	14.59	16.18	10.85	9.07	10.70	6.76	10.94	7.96	11.04	4.25	7.12	......
Yearly total	24.75	52.61	35.42	28.17	42.76	37.03	34.46	29.39	34.36	21.98	26.50	32.50

a Mean of—
Utica 3.12
Palermo 2.25
2)5.37
2.68

b Watertown record.

Table No. 103.—*Record of precipitation at Salem for certain water years, as indicated, from 1840 to 1847, inclusive.*

Month.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	Mean.
December	a 1.98	1.19	1.11	1.76	1.57	3.27	3.94	3.00	....
January	0.99	3.63	....	1.30	2.09	1.80	1.94	1.51	....
February	1.37	0.30	....	1.75	1.45	2.34	0.95	1.36	....
March	3.79	2.15	....	4.36	2.34	2.56	2.56	2.37	....
April	2.66	3.78	....	2.38	1.07	0.81	0.45	1.10	....
May	1.47	2.37	....	1.52	3.38	2.42	2.90	2.26	....
Total	12.26	13.42	....	13.07	11.90	13.20	12.74	11.60	....
June	4.26	1.58	....	4.82	3.65	2.02	2.72	5.60	....
July	4.55	2.29	....	4.34	2.26	4.48	8.06	4.80	....
August	3.26	2.20	....	6.52	1.53	2.40	0.71	5.04	....
Total	12.07	6.07	....	15.68	7.44	8.90	11.49	15.44	....
September	4.13	4.68	....	1.70	2.98	3.25	2.95	3.51	....
October	4.29	0.33	....	5.41	4.85	1.90	1.55	4.65	....
November	2.92	1.36	....	3.43	0.99	3.20	3.63	1.73	....
Total	11.34	6.37	....	10.54	8.82	8.35	8.13	9.89	....
Yearly total	35.67	25.86	....	39.29	28.16	30.45	32.36	36.93	32.67

a Granville record.

Table No. 104.—*Record of precipitation at Saranac Lake for certain water years, as indicated, from 1889 to 1898, inclusive.*

Month.	1889.	1890.	1894.	1895.	1896.	1897.	1898.	Mean.
December	*a* 3.10	3.12	*b* 5.75	2.27	3.49	1.44	2.22	....
January	5.43	....	2.77	1.84	1.11	2.48	3.39	....
February	3.59	....	1.96	1.22	4.28	1.50	2.48	....
March	2.96	....	2.04	1.37	4.31	2.70	1.25	....
April	2.15	....	0.75	2.30	1.37	3.79	2.65	....
May	2.28	....	4.41	4.34	2.47	3.41	3.23	....
Total	19.51	....	17.68	13.34	17.03	15.32	15.22	....
June	5.85	....	5.06	3.25	3.70	3.75	4.06	....
July	4.25	....	3.44	2.46	4.19	8.55	3.16	....
August	2.72	....	1.58	4.61	2.68	2.56	4.79	....
Total	12.82	....	10.08	10.32	10.57	14.86	12.01	....
September	3.69	....	3.58	3.56	4.75	2.75	4.05	....
October	4.17	....	4.10	1.68	1.76	1.41	3.50	....
November	2.21	....	2.75	4.43	2.80	4.74	2.76	....
Total	10.07	....	10.43	9.67	9.31	8.90	10.31	....
Yearly total	42.40	....	38.19	33.33	36.91	39.08	37.54	37.91

a Glens Falls record. *b* Mean of Northern Plateau.

Table No. 105.—*Record of precipitation at Skaneateles for the water years 1894 to 1898, inclusive.*

Month.	1894.	1895.	1896.	1897.	1898.	Mean.
December	....	2.16	3.92	1.44	3.48	....
January	....	2.79	2.08	1.77	3.69	....
February	....	2.86	3.84	1.45	2.10	....
March	....	2.23	5.56	4.13	2.58	....
April	....	1.86	0.97	3.16	3.63	....
May	....	2.58	2.15	3.31	5.28	....
Total	....	14.48	18.52	15.26	20.76	....
June	....	2.04	2.31	3.15	3.50	....
July	....	2.90	5.39	4.92	1.91	....
August	....	4.28	4.05	2.09	6.17	....
Total	....	9.22	11.75	10.16	11.58	....
August	5.68	1.91	5.08	2.73	5.53	....
September	3.79	0.82	3.48	0.95	5.20	....
October	1.72	3.46	2.73	5.70	3.95	....
Total	11.19	6.19	11.29	9.38	14.68	....
Yearly total	....	29.89	41.56	34.80	47.02	38.32

TABLE NO. 106.—*Record of precipitation at South Canisteo for the water years 1889 to 1898, inclusive.*

Month.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	......	4.00	4.00	3.30	1.01	2.91	3.41	4.34	1.14	2.71	......
January	0.80	3.89	2.53	3.50	2.96	3.41	3.32	2.76	2.34	3.90	......
February	......	2.67	4.72	3.40	3.58	3.21	0.97	5.62	1.60	2.09	......
March	......	4.48	3.43	3.42	3.51	1.64	1.63	3.71	3.01	4.53	......
April	4.96	4.22	2.22	1.57	5.84	7.80	1.49	1.25	3.13	3.35	......
May	5.90	8.64	1.41	6.74	5.25	11.46	2.79	4.03	3.18	3.87	......
Total	......	27.90	18.31	21.93	22.15	30.43	13.61	21.71	14.40	20.45	......
June	7.19	5.03	2.68	3.99	4.78	3.51	4.75	6.22	3.48	2.90	......
July	9.25	2.31	4.62	4.56	2.70	3.34	2.77	5.01	5.62	1.75	......
August	3.12	7.41	5.80	4.83	4.13	2.71	3.88	1.62	2.69	4.45	......
Total	19.56	14.75	13.10	13.38	11.61	9.56	11.40	12.85	11.79	9.10	......
September	4.56	12.72	1.20	1.40	2.76	7.12	1.15	5.10	3.47	2.28	......
October	4.59	6.51	3.48	2.44	4.05	4.40	1.17	6.49	1.04	4.80	......
November	6.32	1.90	2.74	3.60	2.07	2.13	3.49	1.82	3.56	3.33	......
Total	15.47	21.13	7.42	7.44	8.88	13.65	5.71	13.41	8.07	10.41	......
Yearly total	......	63.78	38.83	42.75	42.64	53.64	30.72	47.97	34.26	39.96	43.84

TABLE NO. 107.—*Record of precipitation at South Hartford for certain water years, as indicated, from 1863 to 1879, inclusive.*

Month.	1863.	1964.	1865.	1866.	1867.	1868.	1869.	1870.
December	....	3.23	4.40	3.55	3.62	1.20	3.70	4.15
January	....	1.56	2.60	1.18	1.41	4.00	3.40	2.87
February	....	1.75	1.80	4.74	2.85	1 10	4.85	3.72
March	....	2.95	6.08	1.94	1.95	2.45	5.15	3.58
April	....	5.75	3.30	0.68	4.59	2.85	1.60	1.85
May	....	6.53	7.53	1.06	8.50	6.20	2.10	0.65
Total	....	21.77	25.71	13.15	22.92	17.80	20.30	16.82
June	....	0.82	3.99	3.65	10.95	2.90	5.03	3.35
July	....	1.95	4.56	2.46	3.73	0.80	3.12	3.70
August	10.12	7.68	0.95	4.34	2.50	1.84	*a* 1.76	1.45
Total	....	10.45	9.50	10.45	17.18	5.54	9.91	8.50
September	2.80	4.55	2.08	5.28	1.30	*b* 6.50	3.10	2.15
October	2.60	4.55	2.27	1.07	2.72	2.71	13.85	2.95
November	2.13	6.90	4.98	4.98	3.00	8.30	2.50	1.12
Total	7.53	16.00	9.31	11.31	7.02	17.51	19.45	6.22
Yearly total	....	48.22	44.52	34.91	47.12	40.85	49.66	31.54

Month.	1871.	1872.	1873.	1875.	1876.	1877.	1878.	1879.	Mean.
December	1.72	3.72	3.86	....	1.90	3.18	0.25	5.15	3.12
January	2.52	1.03	3.42	....	2.53	2.90	5.05	3.00	2.68
February	2.51	1.95	2.90	....	4.85	0.42	1.70	....	2.66
March	3.38	2.33	3.05	....	4.91	2.95	1.70	....	3.26
April	1.95	2.05	3.25	....	2.15	1.95	3.25	....	2.71
May	2.10	4.65	1.80	....	2.75	2.17	2.50	....	3.73
Total	14.18	15.73	18.28	....	19.09	13.57	14.45	....	18.16
June	3.05	6.40	0.95	....	4.30	4.85	3.30	....	4.12
July	5.45	4.15	4.15	....	5.30	4.85	4.35	....	3.74
August	9.10	7.15	3.15	4.90	1.85	3.40	6.30	....	....
Total	17.60	17.70	8.25	....	11.45	13.10	13.95	....	....
September	2.00	1.60	3.20	3.35	5.70	0.55	0.77	....	....
October	3.50	2.90	4.45	6.90	1.20	4.75	4.21	....	4.04
November	2.15	3.40	4.52	4.65	0.80	4.95	3.61	....	3.86
Total	7.65	7.90	12.17	14.90	7.70	10.25	8.59	....	....
Yearly total	39.43	41.33	38.70	....	38.24	36.92	36.99	....	40.65

a Troy record.   *b* Williamstown, Mass., record.

TABLE NO. 108.—*Record of precipitation at South Kortright for the water years 1889 to 1898, inclusive.*

Month.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	*a*3.35	1.94	5.25	4.57	1.11	1.09	3.08	3.23	1.37	4.02	......
January	*a*4.45	2.95	4.67	3.30	1.27	2.28	1.76	*b*2.26	0.94	2.84	......
February	0.86	2.06	3.31	1.02	4.22	1.19	1.40	4.81	1.53	2.38	......
March	1.38	3.22	2.37	2.32	2.82	1.25	1.60	3.76	2.59	1.82	......
April	2.55	1.86	1.65	0.77	3.35	2.25	3.31	1.48	2.91	2.54	......
May	4.18	5.24	3.57	6.35	5.81	6.67	2.19	2.94	5.33	4.06	......
Total	16.77	17.27	20.82	18.33	18.58	15.63	13.34	18.48	14.67	17.06	......
June	6.02	4.66	3.04	2.80	5.76	4.16	1.53	2.75	5.00	3.70	......
July	5.52	2.31	3.67	5.14	3.50	4.10	3.11	5.50	5.56	2.56	......
August	3.26	5.11	4.21	6.55	7.26	0.84	4.68	2.12	6.03	8.21	......
Total	14.80	12.08	10.92	14.49	16.52	9.10	9.32	10.37	16.59	14.47	......
September	3.80	5.64	1.45	2.98	3.76	3.08	2.69	3.68	4.67	2.98	......
October	3.31	4.86	2.58	1.13	2.05	4.04	2.71	2.35	0.98	5.23	......
November	4.42	1.81	2.63	2.61	1.10	2.30	3.70	2.83	4.35	3.88	......
Total	11.53	12.31	6.66	6.72	6.91	9.42	9.10	8.86	10.00	12.09	......
Yearly total	43.10	41.66	38.40	39.54	42.01	34.15	31.76	37.71	41.26	44.22	39.38

a Middleburg record.

b Bloomville record.

TABLE NO. 109.—*Record of precipitation at South Trenton for certain water years, as indicated, from 1863 to 1876, inclusive.*

Month.	1863.	1864.	1865.	1866.	1867.	1868.	1869.	1870.
December	....	2.02	3.72	*a*3.27	4.10	9.35	3.01	4.30
January	....	4.50	....	2.65	2.20	6.60	5.57	4.97
February	....	4.25	....	5.75	6.49	2.60	3.55	3.91
March	....	6.35	....	4.25	5.30	4.60	4.86	6.68
April	....	7.20	....	1.31	5.54	3.04	4.91	2.54
May	....	2.75	....	4.21	7.62	7.54	3.71	2.77
Total	....	27.07	....	21.44	31.25	33.73	28.51	25.17
June	....	5.40	....	7.14	5.30	3.82	6.46	3.81
July	....	5.77	....	5.07	0.86	*b*5.16	10.70	6.50
August	5.25	1.22	....	4.49	3.34	*b*5.74	5.22	7.01
Total	....	12.39	....	16.70	9.50	14.72	22.38	17.32
September	....	3.97	....	8.07	5.18	7.15	5.28	1.18
October	....	4.78	....	2.84	3.84	2.59	5.84	8.00
November	4.00	2.42	....	5.34	4.86	4.74	6.61	3.39
Total	....	11.17	....	16.25	13.88	14.48	17.73	12.57
Yearly total	....	50.63	....	54.39	54.63	62.93	66.62	55.06

a Mean of—

Oneida	3.76
Pierpont Manor	2.65
Depauville	4.35
Gouverneur	2.50
Palermo	3.10
	5)16.36
	3.27

b Mean of—

Oneida	5.97	6.60	5.40
Houseville	4.35	4.88	6.31
	2)10.32	11.48	11.71
	5.16	5.74	5.85

TABLE No. 109.—*Record of precipitation at South Trenton for certain water years, as indicated, from 1863 to 1876, inclusive*—Continued.

Month.	1871.	1872.	1873.	1874.	1875.	1876.	Mean.
December	2.45	2.00	3.13	*a* 6.81	2.61	2.39	....
January	2.70	1.35	3.00	5.42	2.27	*b* 3.72	....
February	5.19	5.60	*c* 2.36	8.21	9.07	7.82	....
March	7.34	2.57	5.32	3.83	2.33	3.81	....
April	4.41	*c* 1.05	1.12	3.00	3.39	4.85	....
May	2.97	3.59	2.62	3.59	*a* 4.12	5.56	....
Total	25.06	16.16	17.55	30.86	23.79	28.15	....
June	*a* 5.76	4.40	3.07	5.79	*a* 4.89	4.76	....
July	4.00	5.00	6.82	7.23	5.71	4.60	....
August	*d* 5.85	5.58	4.87	3.23	5.17	2.34	....
Total	15.61	14.98	14.76	16.25	15.77	11.70	....
September	2.32	3.27	2.75	1.70	4.37	*b* 5.86	....
October	3.86	5.12	6.67	2.17	*a* 5.33	2.85	....
November	5.43	3.66	4.72	2.85	5.80	*b* 2.85	....
Total	11.61	12.05	14.14	6.72	15.50	11.56	....
Yearly total	52.28	43.19	46.45	53.83	55.15	51.41	53.88

a Mean of—

Oneida	8.73	6.97	4.17	7.56	8.45
Depauville	2.80	6.65	4.08	2.22	2.21
	2)11.53	13.62	8.25	9.78	10.66
	5.76	6.81	4.12	4.89	5.33

b Mean of—

Oneida	3.95	7.33	2.20
Palermo	3.50	4.40	3.50
	2)7.45	11.73	5.70
	3.72	5.86	2.85

c Mean of—

Palermo	1.10	3.10
Depauville	1.00	1.63
	2)2.10	4.73
	1.05	2.36

d Mean of—

Oneida	5.97	6.60	5.40
Houseville	4.35	4.88	6.31
	2)10.32	11.48	11.71
	5.16	5.74	5.85

TABLE No. 110.—*Record of precipitation at Theresa for certain water years as indicated, from 1863 to 1868, inclusive.*

Month.	1863.	1864.	1865.	1866.	1867.	1868.	Mean.
December	*a* 3.01	3.45	5.18	2.81	5.16	1.83	....
January	2.89	2.78	1.13	2.25	2.00	2.06	....
February	3.40	*b* 1.62	1.29	2.90	1.90	1.95	....
March	2.99	1.79	3.60	....	6.90	2.22	....
April	2.59	4.75	3.73	....	1.13	2.43	....
May	2.65	8.00	3.03	....	....	....	....
Total	17.53	22.39	18.02	....	....	....	....
June	2.38	0.77	4.04	....	....	....	....
July	1.28	0.76	2.71	....	....	....	....
August	2.41	3.49	1.22	....	....	....	....
Total	6.07	5.02	7.97	....	....	....	....
September	2.62	4.30	2.67	5.58	....	....	....
October	3.87	6.28	4.36	3.01	....	....	....
November	4.91	5.42	3.01	4.86	2.57	....	....
Total	11.40	15.98	10.04	13.45	....	....	....
Yearly total	35.00	43.39	36.03	....	....	....	38.14

a Mean of—

Gouverneur	2.82
Pierpont Manor	3.21
	2)6.03
	3.01

b Mean of—

Gouverneur	1.70
Pierpont Manor	1.53
	2)3.23
	1.62

TABLE NO. 111.—*Record of precipitation at Turin for the water years 1890 to 1896, inclusive.*

Month.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	Mean.
December	5.14	6.74	7.00	2.99	6.93	3.24	4.28	....
January	7.15	5.86	6.39	3.78	3.81	5.51	4.42	....
February	4.83	7.60	4.33	6.33	3.79	3.21	9.11	....
March	3.30	4.18	4.02	3.40	2.76	3.23	4.63	....
April	1.82	2.58	1.83	4.13	2.58	0.87	1.48	....
May	5.69	1.81	5.80	6.39	5.79	3.32	2.96	....
Total	27.93	28.77	29.37	27.02	25.66	19.38	26.88	....
June	4.09	3.25	5.43	4.25	4.70	1.64	....	....
July	7.47	6.94	4.92	2.58	2.59	2.85	....	....
August	5.40	4.92	9.00	7.09	1.54	4.42	....	....
Total	16.96	15.11	19.35	13.92	8.83	8.91	....	....
September	7.32	2.05	3.37	3.36	4.51	3.99	....	....
October	5.47	3.60	2.05	1.97	6.36	3.71	....	....
November	4.99	7.03	4.95	3.80	3.38	5.27	....	....
Total	17.78	12.68	10.37	9.13	14.25	12.97	....	....
Yearly total	62.67	56.56	59.09	50.07	48.74	41.26	....	53.06

TABLE NO. 112.—*Record of precipitation at Utica for certain water years, as indicated, from 1826 to 1893, inclusive.*

Month.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.
December	a 3.06	6.37	3.00	0.31	3.37	2.84	3.88	5.15	2.61	1.89	1.16	2.51
January	3.46	3.36	1.79	2.82	2.94	3.10	3.13	2.17	1.89	3.31	8.06	......
February	2.10	2.94	2.70	3.00	0.52	2.64	1.96	2.68	1.21	1.79	2.65	......
March	3.37	1.92	0.89	2.00	5.61	1.90	1.45	1.39	2.68	1.93	0.51	......
April	1.30	5.18	1.41	4.57	2.18	5.33	1.65	0.73	3.83	3.67	2.60	......
May	0.93	3.97	0.75	0.35	4.97	2.92	2.20	4.30	3.23	2.18	4.33	......
Total	14.22	23.74	10.54	13.05	19.59	18.73	18.27	16.42	15.45	14.77	19.31	......
June	7.46	3.42	5.16	3.40	7.93	3.23	1.90	2.46	5.99	6.88	3.00	......
July	3.36	7.60	7.54	3.97	5.44	6.09	3.64	6.03	3.20	4.89	1.72	......
August	0.72	4.99	4.99	2.11	2.10	4.38	11.44	3.96	3.97	6.50	0.91	......
Total	11.54	16.01	17.69	9.48	15.47	13.70	16.98	12.45	13.16	18.27	5.63	......
September	2.63	4.05	4.29	4.96	2.66	1.48	4.55	3.76	2.85	1.38	3.57	......
October	1.93	4.50	2.59	2.88	2.42	1.33	2.52	4.66	2.09	2.32	1.27	......
November	2.48	2.99	4.15	2.73	6.58	1.57	6.31	3.04	1.69	2.60	1.97	......
Total	7.04	11.54	11.03	10.57	11.66	4.38	13.38	11.46	6.63	6.30	6.81	......
Yearly total	32.80	51.29	39.26	33.10	46.72	36.81	48.63	40.33	35.24	39.34	31.75	......

(*a* Mean of Decembers from 1826 to 1847.)

Table No. 112.—*Record of precipitation at Utica for certain water years, as indicated, from 1826 to 1893, inclusive*—**Continued.**

Month.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	19 years' mean.	1851.	1852.
December	*a* 0.43	3.88	3.09	6.25	2.97	3.51	2.64	2.10	3.25	3.06	......	5.22
January	4.12	1.75	2.66	2.40	2.48	0.98	3.58	1.50	......	......	......	3.75
February	1.27	6.20	0.75	4.80	1.96	1.70	2.75	2.00	......	......	4.36	1.96
March	1.25	5.33	3.25	4.81	5.62	3.55	3.30	1.54	......	......	......	3.34
April	1.49	6.60	4.98	6.69	2.74	0.97	3.54	0.90	......	......	......	3.43
May	4.11	3.18	2.37	5.01	5.50	4.67	3.80	4.72	......	......	2.77	3.50
Total	12.67	26.94	17.10	29.96	21.27	15.38	19.61	12.76	......	......	......	21.20
June	3.87	3.97	4.04	5.52	8.88	2.55	4.83	2.96	......	......	7.00	2.65
July	3.55	3.34	2.85	7.35	4.75	2.86	2.88	4.93	......	......	7.96	5.92
August	1.58	4.17	4.60	3.67	3.12	3.11	1.47	2.53	......	......	......	*b* 2.80
Total	9.00	11.48	11.49	16.54	16.75	8.52	9.18	10.42	......	......	......	11.37
September	1.68	4.08	3.86	6.91	2.17	2.40	4.07	6.06	......	......	......	1.82
October	2.15	2.55	2.21	3.00	3.34	4.70	3.48	2.88	......	......	3.23	3.67
November	6.49	1.55	5.03	3.19	3.45	1.76	4.58	3.10	......	......	4.99	5.65
Total	10.32	8.18	11.10	13.10	8.96	8.86	12.13	12.04	......	......	......	11.14
Yearly total	31.99	46.60	39.69	59.60	46.98	32.76	40.92	35.22	......	(40.48)	......	43.71

Month.	1853.	1854.	1860.	1861.	1862.	1863.	1864.	1881.	1882.	1883.	1884.
December	4.89	1.75	......	1.39	1.16	2.54	2.67	*b* 2.77	8.72	3.38	2.42
January	*c* 2.46	3.00	......	2.10	4.50	6.16	......	1.90	2.63	1.85	2.90
February	2.15	2.44	......	2.13	2.43	3.05	......	2.67	2.04	3.03	4.84
March	3.80	4.18	......	2.41	5.33	2.41	......	2.08	4.78	0.66	4.02
April	2.51	......	......	3.13	1.74	1.33	......	0.60	1.39	0.71	1.31
May	3.83	......	3.54	4.32	4.26	3.53	......	3.69	5.12	4.26	4.95
Total	19.64	......	......	15.48	19.42	19.02	......	13.71	24.68	13.89	20.44
June	1.44	......	......	1.74	3.51	2.00	......	2.59	7.52	5.38	1.13
July	*c* 3.08	......	5.52	8.22	4.57	5.95	......	3.83	3.62	5.10	2.84
August	2.28	......	3.46	2.32	1.77	5.44	......	1.56	1.62	1.21	3.38
Total	6.80	......	......	12.28	9.85	13.39	......	7.98	12.76	11.69	7.35
September	5.51	......	3.24	4.48	2.04	3.48	......	2.51	3.22	4.16	2.62
October	2.81	......	3.68	5.92	5.67	2.56	......	6.67	1.25	3.61	4.23
November	7.27	......	5.52	2.62	5.13	4.28	......	4.22	2.28	3.89	2.86
Total	15.59	......	12.44	13.02	12.84	10.32	......	13.40	6.75	11.66	9.76
Yearly total	42.03	......	......	40.78	42.11	42.73	......	35.09	44.19	37.24	37.55

a Whitestown record.

b Mean of—

North Volney	2.00
Oswego	4.24
Palermo	1.88
Sacketts Harbor	2.96
	4)11.08
	2.77

c Clinton record.

TABLE NO. 112.—*Record of precipitation at Utica for certain water years, as indicated, from 1826 to 1893, inclusive*—Continued.

Month.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	12 years' mean.	Mean of 36 years.
December	5.06	3.76	1.72	4.08	3.12	3.31	5.90	6.77	1.98	......	......
January	2.32	2.42	4.65	3.35	4.32	6.14	4.18	5.78	1.92	......	......
February	2.28	1.33	7.04	2.98	4.04	4.79	5.35	3.37	7.79	......	......
March	0.76	3.36	2.76	4.62	3.25	4.15	3.77	4.65	3.16	......	......
April	1.92	3.06	2.49	2.87	2.71	3.56	1.53	2.14	3.48	......	......
May	4.26	2.63	2.28	4.09	2.49	8.69	1.53	7.00	7.84	......	......
Total	16.58	16.56	20.94	21.97	19.93	30.64	22.26	29.71	26.17	......	......
June	3.09	3.41	2.06	4.55	9.19	6.19	2.60	6.20	2.35	......	......
July	6.68	6.37	4.05	1.56	5.49	3.01	3.79	6.00	5.32	......	......
August	7.04	2.51	3.68	3.85	1.72	4.37	3.32	7.95	6.57	......	......
Total	16.81	12.29	9.79	9.96	16.40	13.57	9.71	20.24	14.24	......	......
September	2.14	5.98	2.50	3.62	3.93	8.25	1.46	3.72	......	......	......
October	7.95	3.60	1.96	5.52	3.91	7.01	3.64	2.59	......	......	......
November	4.99	7.10	4.05	4.90	3.83	3.77	3.30	4.28	......	......	......
Total	15.08	16.77	8.51	14.04	11.67	19.03	8.40	10.59	......	......	......
Yearly total	48.47	45.62	39.24	45.97	48.00	63.24	40.37	60.54	......	(45.46)	42.39

TABLE NO. 113.—*Record of precipitation at Waterford, for certain water years, as indicated, from 1857 to 1863, inclusive.*

Month.	1857.	1858.	1859.	1860.	1861.	1862.	1863.	Mean.
December	....	3.79	2.58	3.78	[a]2.30	1.47	1.26	....
anuary	....	2.07	3.22	....	3.15	4.03	4.64	....
February	....	1.33	2.01	....	2.27	2.22	2.03	....
March	....	0.60	3.14	....	3.80	3.54	3.66	....
April	....	2.95	3.81	....	5.67	1.97	....	....
May	....	3.65	1.58	....	3.99	1.07	5.48	....
Total	....	14.39	16.34	....	21.18	14.36	....	....
June	4.78	2.74	4.24	....	1.72	7.70	....	....
July	4.53	6.62	2.41	....	5.33	4.00	....	....
August	5.19	3.40	2.66	....	3.54	2.98	....	....
Total	14.50	12.76	9.31	....	10.59	14.68	....	....
September	2.93	3.77	4.27	....	2.79	1.00	....	....
October	4.85	2.42	0.76	....	3.22	3.08	....	....
November	1.40	3.10	3.11	....	2.37	3.05	....	....
Total	9.18	9.29	8.14	....	8.38	7.13	....	....
Yearly total	....	36.44	33.79	....	40.15	36.11	....	36.62

[a] Troy record.

Table No. 114.—*Record of precipitation at Watertown for the water years 1862 to 1898, inclusive.*

Month.	1862.	1863.	1864.	1865.	1866.	1867.	1868.	1869.	1870.	1871.	1872.	1873.	1874.
December	a1.59	3.21	3.03	4.23	2.65	4.96	0.92	1.19	2.41	3.61	2.22	2.37	1.71
January	2.33	2.57	2.46	2.64	2.24	1.26	3.26	0.90	3.67	0.84	1.09	3.29	6.15
February	2.30	2.92	1.33	0.58	2.64	1.70	0.77	0.94	2.25	1.55	1.15	0.80	2.14
March	2.83	2.35	2.23	4.16	2.70	0.68	1.52	1.35	2.11	2.74	2.30	4.55	2.33
April	1.28	2.15	3.31	3.71	2.19	1.96	0.64	0.94	0.80	2.55	0.86	1.90	1.95
May	2.33	3.12	5.92	2.60	3.17	5.67	3.47	2.96	1.12	1.42	2.35	1.00	0.82
Total	12.66	16.32	18.28	17.92	15.59	16.23	10.58	8.28	12.36	12.71	9.97	13.91	15.10
June	1.39	3.35	0.78	4.81	6.25	0.71	1.76	2.69	1.73	1.56	2.88	4.03	2.34
July	3.68	3.37	0.80	2.62	1.79	2.42	1.93	5.21	1.56	2.74	2.05	2.40	4.37
August	1.25	3.60	5.14	1.43	6.52	1.55	1.16	0.98	1.46	6.84	3.33	0.80	1.00
Total	6.32	10.32	6.72	8.86	14.56	4.68	4.85	8.88	4.75	11.14	8.26	7.23	7.71
September	2.58	2.99	2.74	3.27	6.86	3.21	3.11	5.17	4.42	2.33	2.74	1.74	2.57
October	3.26	5.85	4.29	6.15	3.66	1.20	2.29	1.55	1.66	1.35	4.70	4.50	4.77
November	1.85	4.57	5.70	3.21	7.30	0.90	5.51	2.36	1.26	2.96	2.74	2.58	2.36
Total	7.69	13.41	12.73	12.63	17.82	5.31	10.91	9.08	7.34	6.64	10.18	8.82	9.70
Yearly total	26.67	40.05	37.73	39.41	47.97	26.22	26.34	26.24	24.45	30.49	28.41	29.96	32.51

Month.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.
December	0.92	1.37	2.09	1.37	6.05	2.46	2.80	3.88	2.78	2.31	4.50	4.81	3.50
January	1.80	1.71	2.60	2.42	1.34	2.64	2.30	1.67	2.95	3.37	4.53	2.96	3.39
February	1.38	3.85	0.47	1.40	1.21	2.51	2.52	1.83	3.28	3.06	2.65	2.25	3.68
March	1.60	4.30	2.92	1.82	1.46	1.97	2.64	2.43	1.70	2.34	1.47	4.18	1.51
April	1.20	2.12	1.60	1.76	0.48	1.78	0.40	1.31	1.37	0.41	3.58	3.75	1.98
May	2.92	1.42	1.86	1.93	1.67	2.67	4.07	4.13	5.04	2.66	1.77	2.46	1.98
Total	9.82	14.77	11.54	10.70	12.21	14.03	14.73	15.25	17.12	14.15	18.50	20.41	16.04
June	1.12	1.91	1.47	1.43	1.84	1.88	2.34	2.61	2.22	0.51	3.70	2.22	1.52
July	1.56	2.09	1.64	4.60	1.28	1.70	1.04	2.38	4.57	3.49	3.34	2.49	1.59
August	2.29	0.30	2.27	8.37	1.89	2.20	0.99	3.40	1.95	4.98	2.38	3.05	1.05
Total	4.97	4.30	5.38	14.40	5.01	5.78	4.37	8.39	8.74	8.98	9.42	7.76	4.16
September	2.46	2.52	2.30	1.53	1.22	2.71	1.14	2.30	2.70	3.02	3.48	4.91	2.00
October	2.44	2.41	0.92	4.15	0.52	4.27	2.31	0.62	2.78	2.44	4.15	1.23	2.40
November	1.47	1.22	2.46	3.84	4.40	2.39	2.94	1.72	1.84	3.31	3.50	4.34	2.12
Total	6.37	6.15	5.68	9.52	6.14	9.37	6.39	4.64	7.32	8.77	11.13	10.48	6.52
Yearly total	21.16	25.22	22.60	34.62	23.36	29.18	25.49	28.28	32.18	31.90	39.05	38.65	26.72

Month.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	2.83	3.08	3.29	2.54	4.20	3.49	5.01	2.53	5.09	1.52	4.71	......
January	1.50	3.87	4.41	3.36	5.01	2.54	3.34	3.77	2.92	2.53	5.65	......
February	1.34	2.17	2.78	2.79	2.44	3.68	2.12	1.40	6.43	2.68	2.26	......
March	2.68	1.52	2.04	4.14	2.68	3.14	2.77	1.70	4.84	4.03	1.79	......
April	1.17	1.89	1.93	1.43	1.28	3.21	1.63	2.40	1.46	3.60	2.09	......
May	1.30	5.49	5.44	0.92	5.43	6.24	4.77	3.15	2.56	4.43	3.41	......
Total	10.82	18.02	19.89	15.18	21.04	22.30	19.64	14.95	23.30	18.79	19.91	......
June	1.71	4.00	2.75	1.66	5.03	2.66	4.59	2.11	3.65	1.99	1.69	......
July	1.85	4.40	2.08	7.66	5.07	1.98	3.28	3.94	4.02	5.56	1.57	......
August	4.08	1.72	4.81	4.08	10.25	7.86	9.66	4.67	3.44	2.04	4.59	......
Total	7.64	10.12	9.64	13.40	20.35	12.50	8.53	10.72	11.11	9.59	7.85	......
September	1.89	4.00	7.23	2.79	3.94	2.03	5.00	4.31	4.24	1.44	4.05	......
October	3.20	3.35	2.80	3.64	2.34	1.99	6.72	2.45	1.78	0.86	4.22	......
November	5.23	5.00	3.48	4.55	5.66	3.08	2.14	4.82	4.41	4.87	3.13	......
Total	10.32	12.35	13.51	10.98	11.94	7.10	13.86	11.58	10.43	7.17	11.40	......
Yearly total	28.78	40.49	43.04	39.56	53.33	41.90	42.03	37.25	44.84	35.55	39.16	33.53

a Rutland record.

TABLE No. 115.—*Record of precipitation at Waverly for the water years 1890 to 1898, inclusive.*

Month.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	*a* 2.38	4.34	3.54	0.70	3.18	2.56	3.71	1.01	2.70	......
January	2.25	3.23	3.99	2.25	2.39	2.56	1.66	1.72	2.65	......
February	2.18	2.88	1.53	2.73	2.64	1.15	4.07	1.67	1.70	......
March	3.33	2.84	2.98	2.89	1.35	1.60	3.40	1.89	2.43	......
April	2.65	1.83	0.87	3.39	4.63	1.83	1.18	3.10	3.55	......
May	5.62	0.59	5.95	7.54	6.96	2.89	2.41	3.66	3.86	......
Total	18.41	15.71	18.86	19.50	21.15	12.59	16.43	13.05	16.89	......
June	4.78	4.07	4.70	1.97	1.92	2.98	2.85	3.22	2.28	......
July	3.07	2.36	3.60	3.55	2.19	1.58	5.81	4.50	2.97	......
August	5.82	6.31	4.11	5.29	2.55	3.67	1.57	3.21	5.83	......
Total	13.67	12.74	12.41	10.81	6.66	8.23	10.23	10.93	11.08	......
September	8.24	2.36	2.27	5.57	5.34	1.63	3.57	3.42	1.87	......
October	5.24	4.32	1.35	2.34	5.55	0.85	4.90	0.79	5.85	......
November	0.97	2.07	2.71	1.61	1.95	1.80	2.58	3.69	2.55	......
Total	14.45	8.75	6.33	9.52	12.84	4.28	11.05	7.90	10.27	......
Yearly total	46.53	37.20	37.60	39.83	40.65	25.10	37.71	31.88	38.24	37.19

TABLE No. 116.—*Record of precipitation at Wedgewood for the water years 1889 to 1898, inclusive.*

Month.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	*a* 1.24	2.40	3.84	3.85	0.71	1.71	3.15	3.51	1.42	1.93	......
January	3.53	2.67	2.48	3.50	2.23	3.10	2.30	1.72	1.85	2.73	......
February	2.28	2.52	3.88	2.50	2.49	3.09	0.85	5.02	0.87	1.88	......
March	1.14	4.09	3.11	3.81	2.93	1.00	1.00	3.43	2.54	2.62	......
April	3.02	2.74	2.46	1.08	3.55	6.67	1.55	2.52	2.72	2.91	......
May	3.17	7.04	0.89	5.17	5.37	8.01	2.71	2.98	3.72	3.40	......
Total	14.38	21.46	16.66	19.91	17.28	23.58	11.56	19.18	13.12	15.47	......
June	6.70	3.52	2.43	4.35	5.51	2.59	3.98	6.23	2.74	2.72	......
July	7.16	1.02	2.45	7.24	3.55	2.49	2.31	5.02	3.43	3.48	......
August	4.73	5.48	4.58	4.02	5.61	1.41	8.27	1.54	3.04	4.63	......
Total	18.59	10.02	9.46	15.61	14.67	6.49	14.56	12.79	9.21	10.83	......
September	2.34	8.53	0.66	0.75	2.83	5.91	1.32	5.02	2.66	1.86	......
October	3.31	5.45	4.19	2.20	2.57	4.22	1.02	4.42	0.74	5.95	......
November	4.88	1.58	1.77	3.25	1.60	1.86	3.37	2.03	3.20	2.73	......
Total	10.53	15.56	6.62	6.20	7.00	11.99	5.71	11.47	6.60	10.54	......
Yearly total	43.50	47.04	32.74	41.72	38.95	42.06	31.83	43.44	28.93	36.84	38.70

a Geneva record.

TABLE No. 117.—*Record of precipitation at Whitesboro for the water years 1834 to 1840, inclusive.*

Month.	1834.	1835.	1836.	1837.	1838.	1839.	1840.	Mean.
December	*a*2.61	1.79	2.33	1.60	1.20	0.43	2.36	....
January	2.40	1.77	10.31	1.73	2.02	0.73	0.21	....
February	1.31	1.37	2.97	2.00	0.83	0.36	1.06	....
March	2.26	1.29	0.81	0.76	1.55	0.48	2.61	....
April	2.50	3.09	2.40	0.64	1.08	1.46	4.21	....
May	2.28	0.99	5.15	0.88	3.40	3.99	2.54	....
Total	13.36	10.30	23.97	7.61	10.08	7.45	12.99	....
June	2.92	4.36	4.70	2.95	1.21	3.91	3.69	....
July	3.35	1.98	0.69	3.50	2.63	3.90	7.65	....
August	1.42	2.66	1.08	2.08	3.63	2.25	7.60	....
Total	7.69	9.00	6.47	8.53	7.47	10.06	18.94	....
September	1.23	0.84	4.20	1.13	2.71	1.64	6.05	....
October	2.60	2.39	2.60	3.92	4.21	0.70	6.45	....
November	1.42	1.93	1.44	2.43	2.14	2.41	3.01	....
Total	5.25	5.16	8.24	7.48	9.06	4.75	15.51	....
Yearly total	26.30	24.46	38.68	23.62	20.61	22.26	47.44	29.91

a Utica record.

TABLE No. 118.—*Record of precipitation at Williamstown, Mass., for certain water years, as indicated, from 1852 to 1898, inclusive.*

Month.	1852.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	1861.	1862.	1863.	1864.
December	......	......	1.10	6.63	3.76	3.86	1.74	5.05	3.37	2.13	......	4.13
January	......	......	2.52	2.23	......	2.90	7.33	1.05	1.02	3.65	......	1.24
February	......	......	1.43	0.96	3.68	1.00	1.74	2.37	2.92	......	......	1.49
March	......	......	0.21	1.65	......	1.06	4.02	2.20	4.41	......	......	2.24
April	5.02	......	5.64	2.09	......	2.24	3.88	1.02	5.32	......	......	1.92
May	3.30	......	2.85	6.25	......	3.54	*b*2.19	2.38	5.25	......	.....	1.98
Total	......	......	13.75	19.81	......	14.69	21.50	14.07	22.29	......	......	13.00
June	......	......	5.48	*b*3.44	......	2.82	*b*4.27	4.09	2.08	......	1.53	1.64
July	......	......	6.75	1.27	4.05	4.37	3.46	7.18	6.09	......	9.87	1.91
August	......	......	3.56	14.79	5.19	5.77	2.56	4.86	4.14	......	5.24	4.96
Total	......	......	15.79	19.50	.....	12.96	10.29	16.13	12.31	......	16.64	8.51
September	......	5.18	1.92	4.25	3.32	2.97	3.78	5.07	3.82	......	3.05	3.06
October	......	1.93	12.93	1.20	4.87	3.15	1.31	2.48	4.15	......	2.32	3.58
November	......	4.71	4.59	2.51	1.76	3.11	3.04	4.43	3.17	......	4.26	3.16
Total	......	11.82	19.44	7.96	9.95	9.23	8.13	11.98	11.14	......	9.63	9.80
Yearly total	......	......	48.98	47.27	......	36.88	39.92	42.18	45.74		......	31.31

Month.	1865.	1866.	1867.	1868.	1869.	1870.	1871.	1872.	1875.	1876.	1877.
December	4.18	2.12	3.75	1.55	2.49	4.41	0.76	3.61	......	1.44	3.00
January	*a*2.60	1.01	1.65	2.42	3.52	5.46	1.12	1.05	......	3.52	......
February	1.04	1.78	2.35	1.95	3.78	5.80	1.50	......	......	4.48	0.22
March	5.29	1.76	1.38	1.20	4.44	4.76	3.02	3.56	......	4.68	4.64
April	4.10	0.75	3.96	2.60	3.16	3.29	2.29	......	......	3.52	1.29
May	*a*7.53	3.38	5.90	5.43	3.28	1.27	2.19	......	......	2.69	......
Total	24.74	10.80	18.99	15.15	20.67	24.99	10.88	......	......	21.33	......
June	2.93	4.38	1.47	1.22	3.84	5.05	4.85	......	3.51	6.59	4.22
July	4.83	4.05	3.61	0.37	5.17	3.89	4.72	......	3.94	6.77	......
August	0.65	3.38	5.21	3.40	*b*1.76	5.77	6.53	......	5.06	1.63	......
Total	8.41	11.81	10.29	4.99	10.77	14.71	16.10	......	12.51	14.99	......
September	2.27	4.97	2.20	6.50	3.18	2.24	1.00	......	3.49	3.85	......
October	5.27	2.37	1.27	0.93	10.68	4.30	2.00	......	5.28	0.79	......
November	1.79	4.00	3.39	4.42	1.09	2.25	2.74	......	3.84	3.56	......
Total	9.33	11.34	6.86	11.85	14.95	8.79	5.74	......	12.59	8.20	......
Yearly total	42.48	33.95	36.14	31.99	46.39	48.49	32.72	......	......	43.52	......

a South Hartford, N. Y., record. *b* Troy record.

TABLE No. 118.—*Record of precipitation at Williamstown, Mass., for certain water years, as indicated, from 1852 to 1898, inclusive*—Continued.

Month.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
December	......	3.70	2.59	2.30	5.04	0.96	......	3.72	3.43	4.04	4.30
January	......	2.00	3.30	1.88	2.23	*a*0.98	1.75	6.63	3.92	6.29	2.20
February	......	1.86	2.60	6.19	*b*3.31	2.64	3.76	3.56	2.61	4.50	2.18
March	......	2.37	1.46	2.33	2.35	0.87	3.89	0.96	5.01	5.15	7.89
April	......	3.04	4.77	*b*1.34	1.72	1.98	1.83	3.18	1.56	3.23	2.80
May	......	......	2.58	3.53	4.26	3.81	2.51	2.00	4.77	1.31	3.64
Total	......	......	17.39	17.66	18.91	11.24	......	20.05	21.30	24.52	23.01
June	......	......	1.55	2.08	3.85	3.19	1.65	1.48	2.72	4.33	3.90
July	......	......	4.36	5.16	2.42	4.59	......	2.87	4.20	10.82	1.23
August	3.25	3.93	3.59	1.02	3.26	2.92	......	6.66	1.56	7.03	4.48
Total	......	......	9.50	8.26	9.53	10.70	......	11.01	8.48	22.18	9.61
September	1.62	4.62	3.09	2.26	7.04	2.64	0.58	1.65	4.31	2.30	4.21
October	3.06	0.93	2.46	2.28	0.32	3.32	2.98	3.12	2.60	1.13	5.06
November	4.29	3.43	1.51	3.33	1.18	1.65	2.92	3.97	5.80	3.77	4.12
Total	8.97	8.98	7.06	7.87	8.54	7.61	6.48	8.74	12.71	7.20	13.39
Yearly total	......	......	33.95	33.79	36.98	29.55	......	39.80	42.49	53.90	46.01

Month.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean.
December	3.38	3.30	......	3.59	5.45	5.94	1.75	3.11	1.46	4.61	......
January	*c*2.96	3.41	......	2.68	2.72	2.54	1.87	0.71	2.62	5.25	......
February	1.22	3.92	......	1.13	3.72	2.29	1.70	2.29	1.37	2.15	......
March	1.10	4.06	......	1.75	1.30	1.13	2.10	3.60	2.93	2.47	......
April	2.31	1.46	......	0.40	2.43	1.82	3.90	0.77	3.50	3.60	......
May	1.78	4.68	......	5.43	2.75	3.16	2.10	2.22	4.21	4 10	......
Total	12.75	20.83	......	14.98	18.47	16.88	13.42	12.70	16.09	22.18	......
June	5.08	1.72	......	2.07	2.08	2.99	3.62	2.55	6.61	3.01	......
July	5.81	......	5.43	4.22	1 46	3.30	2.37	2.65	9.74	1.48	......
August	2.94	......	4 48	4.58	5.84	1.46	3.25	3.06	3.40	8.51	......
Total	13.83	......	......	10.87	9.38	7.84	9.24	8.26	19.75	13.00	......
September	2.39	......	0.74	1.68	4.46	4.58	2.22	4.82	2.12	3.22	......
October	2.95	......	1.80	1.57	2.26	4.91	3.74	2.94	0.86	6.99	......
November	4.20	......	1.80	2.90	1.22	*d*0.85	4.12	2.94	6.46	3.25	......
Total	9.54	......	4.34	6.24	7.94	10.34	10.08	10.70	9.44	13.46	......
Yearly total	36.12	......	......	32.00	35.79	35.06	32.74	31.66	45.28	48.64	39.41

a Incomplete. *b* Troy, N.Y., record. *c* Rowe, Mass., record. *d* Williams College record.

TABLE No. 119.—*Statistics of meteorological stations in the State of New York of which precipitation records have been compiled on rainfall map of State.*

Place.	County.	Elevation.	Number of years.	Mean.	Years.	
					From-	To-
Adams	Jefferson	670	9	40.64	1872	1898
Addison	Steuben	1,000	8	32.60	1891	1898
Angelica	Allegany	1,340	10	40.88	1889	1898
Albany	Albany	85	73	39.38	1826	1898
Alfred	Allegany	1,824	9	38.83	1890	1898
Arcade	Wyoming	1,570	8	41.94	1891	1898
Auburn	Cayuga	650	28	35.44	1827	1898
Avon	Livingston	585	5	29.67	1891	1898
Baldwinsville	Onondaga	390	8	39.54	1890	1898
Belleville	Jefferson	300	9	29.76	1830	1845
Binghamton	Broome	270	8	36.98	1890	1898
Bolivar	Allegany	1,800	7	38.92	1891	1898
Bridgewater	Oneida	1,183	4	44.68	1833	1838
Brookfield	Madison	1,350	8	41.30	1890	1898
Burlington, Vt		220	14	32.77	1885	1898
Cambridge	Washington	500	13	40.17	1827	1839
Canandaigua	Ontario	790	10	36.97	1829	1839
Canton	St. Lawrence	304	8	40.49	1889	1898
Cazenovia	Madison	1,176	19	38.76	1830	1850
Cherry Valley	Otsego	1,335	14	41.10	1827	1854
Clinton	Oneida	900	13	42.68	1851	1865

TABLE NO. 119.—*Statistics of meteorological stations in the State of New York of which precipitation records have been compiled on rainfall map of State*—Cont'd.

Place.	County.	Elevation.	Number of years.	Mean.	Years.	
					From—	To—
Constableville	Lewis	1,246	4	56.38	1889	1893
Cooperstown	Otsego	1,234	45	39.07	1854	1898
Cortland	Cortland	1,120	19	42.79	1850	1898
Dekalb Junction	St. Lawrence	440	8	37.97	1890	1898
Demster	Oswego		6	39.13	1890	1897
Depauville	Jefferson	350	10	41.77	1865	1876
Elmira	Chemung	863	17	34.79	1850	1898
Fairfield	Herkimer	1,185	17	36.74	1828	1849
Fleming	Cayuga	1,000	9	32.35	1890	1898
Friendship	Allegany	1,550	5	37.90	1893	1897
Geneva	Ontario	450	25	30.86	1850	1893
Glens Falls	Warren	340	20	37.76	1879	1898
Gloversville	Fulton	800	6	46.10	1892	1898
Gouverneur	St. Lawrence	400	27	30.50	1833	1875
Granville	Washington	409	14	31.51	1835	1849
Hamilton	Madison	1,127	18	34.02	1827	1850
Hartwick	Otsego	1,100	14	37.40	1826	1851
Hemlock Lake	Livingston	900	20	27.56	1876	1895
Houseville	Lewis	900	4	45.38	1865	1871
Hudson	Columbia	150	19	38.41	1827	1856
Humphrey	Cattaraugus	1,950	10	46.09	1889	1898
Ithaca	Tompkins	840	25	33.97	1828	1898
Johnstown	Fulton	688	14	39.99	1828	1845
Keene Valley	Essex	1,000	18	35.93	1879	1898
Kinderhook	Columbia	318	17	36.44	1830	1847
Kings Station	Saratoga	588	8	45.24	1891	1898
Kingston	Ulster	188	19	37.42	1829	1850
Ledyard	Cayuga	447	7	33.21	1827	1851
Leroy	Genesee	888	5	45.25	1891	1895
Liberty	Sullivan	1,500	11	47.98	1850	1863
Little Genesee	Allegany		8	38.39	1866	1874
Lowville	Lewis	900	32	35.04	1827	1898
Lyons	Wayne	407	10	34.40	1889	1898
Malone	Franklin	810	8	37.22	1839	1896
Mexico	Oswego	375	20	36.68	1837	1862
Middleburg	Schoharie	640	5	40.35	1848	1892
Minaville	Montgomery	610	3	42.04	1868	1871
Minnewaska	Ulster	1,800	6	49.20	1891	1898
Mount Morris	Livingston	900	8	27.44	1890	1898
Newark Valley	Tioga	966	8	39.29	1891	1898
New Lisbon	Otsego	1,234	8	39.58	1891	1898
North Hammond	St. Lawrence	300	16	37.23	1866	1898
North Volney	Oswego	350	13	36.15	1872	1886
Number Four	Lewis	1,571	10	51.17	1889	1898
Oneida	Madison	500	11	64.83	1863	1878
Onondaga Hollow	Onondaga	1,260	16	31.55	1826	1845
Oswego	Oswego	304	46	36.65	1844	1898
Oxford	Chenango	1,250	32	39.80	1829	1898
Palermo	Oswego	460	45	37.01	1854	1898
Pen Yan	Yates	740	39	27.93	1829	1867
Perry City	Schuyler	1,038	10	40.09	1889	1898
Phœnix	Oswego		6	38.38	1892	1898
Pierpont Manor	Jefferson	617	22	36.12	1849	1871
Plattsburg	Clinton	156	25	34.56	1843	1898
Pompey	Onondaga	1,300	21	32.37	1827	1858
Port Ontario	Oswego	300	12	31.17	1844	1874
Potsdam	St. Lawrence	300	29	31.83	1828	1898
Poughkeepsie	Dutchess	180	22	38.52	1830	1898
Prattsburg	Steuben	1,494	9	32.71	1829	1846
Rochester	Monroe	575	64	33.61	1830	1898
Rome	Oneida	445	8	47.50	1889	1898
Romulus	Seneca	719	7	35.24	1891	1898
Rondout	Ulster		5	49.02	1889	1894
Rutland	Jefferson	980	16	36.54	1846	1861
Sacketts Harbor	do	266	42	32.50	1841	1898
Salem	Washington	490	7	32.67	1840	1848
Saranac Lake	Franklin	1,600	6	37.91	1889	1898
Skaneateles	Onondaga	932	4	38.32	1894	1898
South Canisteo	Steuben	1,480	9	43.84	1889	1898
South Hartford	Washington	500	13	40.65	1863	1879
South Kortright	Delaware	1,700	10	39.38	1889	1898
South Trenton	Oneida	835	12	53.88	1863	1876
Theresa	Jefferson	365	3	38.14	1863	1868
Turin	Lewis	1,200	6	53.06	1889	1896
Utica	Oneida	473	36	42.39	1826	1893
Waterford	Saratoga	50	4	36.62	1857	1863
Watertown	Jefferson	400	37	33.50	1862	1898
Waverly	Tioga	824	9	37.19	1890	1898
Wedgewood	Schuyler	1,350	10	38.70	1889	1898
Whitestown	Oneida	824	7	29.91	1834	1841
Williamstown, Mass	Berkshire	760	31	39.41	1852	1898
Wyoming	Wyoming	965	17	30.61	1826	1848

Table No. 120.—*Flow of the Hudson River at Mechanicville.*

[In inches on the catchment area.]

Month.	1888.	1889.	1890.	1891.	1892.	1893.
December	2.05	2.57	3.39	0.83	2.27	1.03
January	1.62	2.81	2.89	2.12	4.83	0.82
February	0.89	0.88	1.83	2.70	2.22	1.09
March	1.75	2.12	2.85	4.55	2.80	2.11
April	5.26	3.39	3.73	4.97	5.35	4.44
May	5.49	2.27	4.59	1.42	5.03	5.71
Total	17.06	14.04	19.28	16.59	22.50	15.20
June	1.22	1.70	1.63	0.79	3.08	1.19
July	0.39	1.47	0.50	0.60	2.38	0.65
August	0.44	1.09	0.52	0.68	1.41	1.28
Total	2.05	4.26	2.65	2.07	6.87	3.12
September	0.71	0.49	2.19	0.51	1.10	1.70
October	1.18	0.96	2.36	0.38	0.72	0.99
November	2.64	1.96	2.26	1.01	1.89	0.90
Total	4.53	3.41	6.81	1.90	3.71	3.59
Yearly total	23.64	21.71	28.94	20.56	33.08	21.91

Month.	1894.	1895.	1896.	1897.	1898.	1899.
December	1.85	1.12	2.79	1.77	3.67	1.38
January	1.73	0.90	1.74	1.03	1.97	1.70
February	1.12	0.82	1.12	0.90	1.56	1.22
March	3.78	1.08	3.49	3.13	5.18	8.46
April	2.76	5.91	6.20	4.73	3.40	5.87
May	1.94	1.7[illegible]	1.18	3.04	2.83	2.50
Total	13.18	11.08	16.52	14.60	18.61	15.13
June	1.76	0.70	1.18	2.94	1.30	....
July	0.81	0.66	0.72	2.74	0.64	....
August	0.63	1.00	0.63	2.11	1.30	....
Total	3.20	2.36	2.53	7.79	3.24	....
September	0.47	0.65	0.71	0.68	0.96	....
October	0.94	0.69	1.05	0.65	2.02	....
November	1.58	2.08	2.82	2.47	2.29	....
Total	2.99	3.42	4.58	3.80	5.27	....
Yearly total	19.37	17.46	23.63	26.19	27.12	....

TABLE NO. 121.—*Precipitation on the northern plateau for the water years 1897 and 1898.*

IN COMPARISON WITH THE RUN-OFF OF THE HUDSON RIVER.

[In inches on the catchment area.]

Month.	1897.			1898.		
	Precipitation.	Run-off.	Evaporation.	Precipitation.	Run-off.	Evaporation.
December	1.84	1.77	....	4.59	3.68	....
January	2.93	1.03	....	5.45	1.98	....
February	1.99	0.90	....	3.29	1.56	....
March	4.88	3.13	....	1.89	5.18	....
April	3.72	4.73	....	3.28	3.40	....
May	4.41	3.04	....	4.09	3.57	....
Total	19.77	14.60	5.17	22.59	19.37	3.22
June	4.97	2.94	....	3.78	1.04	....
July	7.36	2.74	....	3.28	0.66	....
August	3.47	2.11	....	6.46	1.31	....
Total	15.80	7.79	8.01	13.52	3.01	10.51
September	2.25	0.68	....	3.67	0.98	....
October	1.70	0.65	....	4.89	2.02	....
November	6.99	2.47	....	3.63	2.29	....
Total	10.94	3.80	7.14	12.19	5.27	6.92
Yearly total	46.51	26.19	20.32	48.30	27.65	20.65

IN COMPARISON WITH THE RUN-OFF OF THE BLACK RIVER.

December	1.84	[a]1.77	....	4.59	3.22	....
January	2.93	[a]1.03	....	5.45	2.38	....
February	1.99	[a]0.90	....	3.29	2.22	....
March	4.88	4.58	....	1.89	6.78	....
April	3.72	5.93	....	3.28	3.09	....
May	4.41	5.08	....	4.09	2.28	....
Total	19.77	19.29	0.48	22.59	19.97	2.62
June	4.97	1.82	....	3.78	1.13	....
July	7.36	0.73	....	3.28	0.86	....
August	3.47	1.48	....	6.46	1.07	....
Total	15.80	4.03	11.77	13.52	3.06	10.46
September	2.25	[a]0.68	....	3.67	1.00	....
October	1.70	0.62	....	4.89	2.22	....
November	6.99	2.54	....	3.63	2.66	....
Total	10.94	3.84	7.10	12.19	5.88	6.31
Yearly total	46.51	27.16	19.35	48.30	28.91	19.39

[a] These data absent from the Black River record. The Hudson River run-off used.

TABLE NO. 122.—*Showing comparative run-offs of Black and Hudson rivers.*

[In inches on their respective catchment areas.]

Month. (1)	1897. Black. (2)	1897. Hudson. (3)	1898. Black. (4)	1898. Hudson. (5)	1899. Black. (6)	1899. Hudson. (7)
December	....	1.77	3.17	3.67	*a*1.67	1.38
January	....	1.03	2.35	1.97	*a*2.88	1.70
February	....	0.90	2.24	1.56	*a*1.32	1.22
March	4.07	3.13	6.63	5.18	*a*3.12	2.46
April	5.44	4.73	3.20	3.40	*a*8.37	5.87
May	4.97	3.04	2.25	2.83	*a*3.57	2.50
Total	14.48	14.60	19.84	18.61	*a*20.93	15.13
June	1.74	2.94	1.15	1.30	....	....
July	0.74	2.74	0.87	0.64	....	....
August	1.44	2.11	1.07	1.30	....	....
Total	3.92	7.79	3.09	3.24	....	....
September	*b*0.68	0.68	1.02	0.96	....	....
October	0.65	0.65	2.16	2.02	....	....
November	2.56	2.47	2.69	2.29	....	....
Total	3.89	3.80	5.87	5.27	....	....
Yearly total	....	26.19	28.80	27.12	....	....

a Computed for these months from Cornell University experiments.
b No Black River record for this month. Assumed the same as Hudson River.

TABLE NO. 123.—*Showing difference or excess of monthly run-off of Black and Hudson rivers.*

[In inches on the catchment areas.]

Month. (1)	1897. Black. (2)	1897. Hudson. (3)	1898. Black. (4)	1898. Hudson. (5)	1899. Black. (6)	1899. Hudson. (7)
December	....	....	....	0.50	*a*0.29	....
January	....	....	0.38	....	*a*1.18	....
February	....	....	0.68	....	*a*0.10	....
March	*b*0.94	....	1.45	....	*a*0.66	....
April	0.71	....	....	0.20	*a*2.50	....
May	1.93	....	....	0.58	*a*1.07	....
Total	....	....	2.51	1.28	*a*5.80	....
June	....	1.20	....	0.15	....	....
July	....	2.00	0.23	....	....	....
August	....	0.67	....	0.23	....	....
Total	....	3.87	0.23	0.38	....	....
September	....	....	0.06	....	....	....
October	....	....	0.14	....	....	....
November	0.09	....	0.40	....	....	....
Total	0.09	....	0.60	....	....	....
Yearly total	....	....	3.34	1.66	....	....

a Computed for months of December, 1898, to May, 1899, inclusive, from Cornell University experiment.
b Black River record began this month.

ON THE METEOROLOGY OF NEW YORK AND THE RELATION OF PRECIPITATION TO RUN-OFF.

At the beginning of the chapter on Run-off Data of Streams in State of New York it is remarked that the proper data for discussing water-supply questions broadly should be derived from gaugings rather than from precipitation records. Indeed, so far as climatic conditions of the eastern United States are concerned, the author is disposed to take the ground that rainfall data alone are inadequate to the making of safe estimates of yields of streams. When, however, we have, in addition to rainfall data, records of actual run-offs determined by gaugings, the two combined may be made the basis of estimates which have substantially the precision of mathematical demonstrations. The chief object of the present chapter is to show the relation between precipitation and run-off for New York streams, as well as to demonstrate the reasonableness of providing ample leeway in the main storage reservoir on Black River.

In Table No. 119 we have the statistics of the several meteorological stations in the State of New York of which the precipitation records have been compiled on plate 98, showing the mean rainfall at points in and adjacent to catchment areas tributary to the proposed deep waterways. In addition to data compiled on plate 98, Table No. 119 shows the years from and to which the several records have been kept, and which data could not well be included on plate 98.

In Tables Nos. 20 to 118, inclusive, we have the precipitation data of the several stations shown by plate 98 and by Table No. 119 in detail. These data are all tabulated with reference to a water year divided into storage, growing, and replenishing periods, the storage period including the months from December to May, inclusive; the growing period June to August, inclusive, and the replenishing period September to November, inclusive. The December of the storage period is the December of the preceding year. Thus for the water year 1872 the month of December is that of 1871.

In Table No. 120 we have the flow of the Hudson River at Mechanicville in inches on the catchment areas for the water years 1888 to the end of the storage period, 1899, inclusive, tabulated with reference to similar storage, growing, and replenishing periods as those in the precipitation Tables Nos. 20 to 118, inclusive. For reasons given in the chapter on Run-off Data of Streams in State of New York, these figures may be taken as substantially applying to Black River.

In Table No. 121 we have given the precipitation in inches on the Northern Plateau in comparison with the run-off of Hudson River in inches on the catchment area for the years 1897 and 1898. Table No. 11 of the author's second report on Hudson River storage, to be found in the Annual Report of the State Engineer and Surveyor of the State of New York for 1896, presents these same data from 1891 to 1896, inclusive, the two tables giving these data from 1891 to 1898, inclusive. Table No. 121 gives for Black River the same data as for Hudson River.

In discussing questions relating to precipitation in the Upper Hudson catchment area it has been the author's custom to take, as best applying to the entire basin, the precipitation of the Northern Plateau as used by the State meteorological bureau, the stations included therein being Elizabethtown, Keene Valley, Lake Placid, Saranac Lake, Gloversville, Little Falls, North Lake, Lowville, Constableville, Houseville, Turin, Number Four, and Kings Station. The monthly mean derived from taking the averages at all these stations is considered to give a very close approximation, not only to the mean monthly rainfall of Upper Hudson area, but of Black and Salmon rivers, East Branch of Fish Creek, and West and East Canada creeks.

Table No. 122 shows the comparative run-offs of Black and Hudson rivers in inches on their respective catchment areas for the water years 1897–98 and for the storage period of the water year 1899.

Table No. 123 shows the difference or excess of monthly run-off of Black and Hudson rivers, in inches, on the catchment areas from December, 1897, to May, 1899, inclusive. For the years 1897 and 1898, so far as we have the data, there is a small excess for Black River, especially in the water year 1898, where it amounts to 1.68 inches. In the storage period of 1899 the excess is 5.8 inches, due, undoubtedly, to the fact that the precipitation of this period was considerably larger on Black River catchment area than on Hudson. As shown, however, in a previous chapter, the excess of Black River may be generally attributed to difference in methods of computation. If both streams were computed on exactly the same basis and with the same degree of accuracy, it is probable that, taking one year with another, only small differences will be found. In the storage period of 1899, however, the considerable difference appearing is undoubtedly due to larger precipitation on Black River catchment area, as is illustrated by the two tabulations following:

Precipitation on Black River catchment area.

Date.	Northern Plateau.	Number Four.	Little Falls Reservoir.	North Lake.	Lowville.	Means of periods, not including Northern Plateau.
Growing period:						
June, 1898	3.78	2.77	4.38	4.56	2.57	....
July, 1898	3.28	2.19	2.42	4.00	1.60	....
August, 1898	6.46	6.56	13.79	5.31	3.61	....
Total	13.52	11.52	20.59	13.87	7.78	13.44
Replenishing period:						
September, 1898	3.67	5.17	3.92	5.35	2.92	....
October, 1898	4.89	6.78	3.78	5.77	5.07	....
November, 1898	3.63	3.49	4.01	4.42	3.41	....
Total	12.89	15.44	11.71	15.54	11.40	13.52
Storage period:						
December, 1898	4.17	7.44	4.67	6.19	4.52	....
January, 1899	3.40	4.53	3.69	3.43	3.64	....
February, 1899	2.38	2.70	3.03	2.92	2.30	....
March, 1899	5.37	5.45	6.33	7.33	5.11	....
April, 1899	1.28	2.15	1.30	2.94	2.01	....
May, 1899	2.46	3.77	4.77	3.72	8.29	....
Total	19.06	26.04	23.79	26.53	20.87	24.31

Precipitation on Hudson River catchment area.

Date.	Saranac Lake.	Keene Valley.	Glens Falls.	Gloversville.	Means of periods.
Growing period:					
June, 1898	4.06	2.50	3.35	5.14	....
July, 1898	3.16	4.04	1.64	4.73	....
August, 1898	4.79	4.25	7.02	6.90	....
Total	12.01	10.79	12.01	16.77	12.90
Replenishing period:					
September, 1898	4.05	3.56	3.42	3.16	....
October, 1898	3.50	3.86	5.28	5.52	....
November, 1898	2.76	2.53	3.59	4.64	....
Total	10.31	9.95	12.29	13.32	11.47
Storage period:					
December, 1898	1.93	1.75	*a* 1.59	2.62	....
January, 1899	2.22	2.15	2.21	3.69	....
February, 1899	1.53	1.33	2.62	2.22	....
March, 1899	3.50	3.38	5.72	7.19	....
April, 1899	0.56	0.83	*b* 2.00	1.38	....
May, 1899	1.15	1.75	*b* 3.25	3.23	....
Total	10.89	11.19	17.39	20.33	14.95

a Missing from record; Lake George record used. *b* Record for King Station used.

The first of these tabulations gives, at the left hand, the precipitation of the entire Northern Plateau from June, 1898, to May, 1899, inclusive. Following this we have four of the principal weather stations of the Black River catchment area, namely, Number Four, Little Falls Reservoir, North Lake, and Lowville. The position of Number Four and Lowville are shown on plate 98. At both of these stations records have been kept for long periods, as shown by the precipitation tables. Little Falls Reservoir is about 8 miles to the north of that place. North Lake is situated considerably farther north on the head waters of main Black River. Little Falls Reservoir and North Lake are not located on plate 98, because records have only been kept there for about the last two years, and consequently we have no safe averages for these places. Probably the precipitation is large in the region covered by these two stations, but this can not be definitely determined until records have been kept for a number of years.

As appears from first tabulation, the total of the growing period of the entire Northern Plateau for 1898 was 13.52 inches, and of the replenishing period, 12.19 inches. The total of the storage period of 1899 is 19.06 inches. For Number Four, Little Falls Reservoir, North Lake, and Lowville the mean total for the growing period of 1898 is 13.44 inches; and of the replenishing period, 13.52 inches; and of the storage period of 1899, 24.31 inches. It seems safe to assume, therefore, that for the period chiefly affecting the run-off during the storage period of 1899 the precipitation of Black River catchment area was about 4 to 5 inches in excess of the mean precipitation of the whole Northern Plateau.

In the second tabulation we have the precipitation at Saranac Lake, Keene Valley, Glens Falls, and Gloversville for the growing and replenishing periods of 1898 and for the storage period of 1899. Comparing the means of the periods with those of the previous tabulation it appears clear that the precipitation for that part of the Northern Plateau, including the Upper Hudson catchment area, was less than the mean of the whole plateau. There appears to be, therefore, sufficient reason why the run-off of Black River during the storage period of 1899 is considerably greater than that of Hudson River for the same period.

In Table No. 131, following, it is shown that for the water year of 1895, which was the dry year of the period from 1892 to 1898 included in the reservoir computations, there would remain in Black River reservoir in store 5.26 inches on the catchment area, or 22,175,000,000 cubic feet. It is also shown by Table No. 136 that, with the alternative tunnel line constructed, there would have been left in Black River reservoir at the end of the water year 1895 7.12 inches on the watershed, equivalent to 30,000,000,000 cubic feet. This apparently large reserve is not held for the benefit of water power, but to cover the contingency of a water year with much smaller run-off than any experienced in the period covered by the gaugings. In case the project is carried out, in making final arrangements with the mill owners on Black River it should be definitely expressed that the reserve storage just referred to is to be held for the purpose stated, nor should the fact of the occurrence of a long series of wet years lead to its use.

On plate 139 we have plotted run-off curves for Hudson and Genesee rivers. These curves are obtained by plotting annual rainfall in inches on the catchment area as abscissas and annual run-off as ordinates. On Hudson River the lowest run-off of 17.46 inches occurred in 1895, in which year the precipitation was 36.8 inches. On Genesee River the lowest run-off, of 6.67, also occurred in 1895, when the precipitation was 31 inches. The broad proposition to be deduced from these curves is that for years when the rainfall sinks as low as about 30 inches the run-off of Hudson River will not exceed 10 inches, and may be somewhat less, and that the run-off of Genesee River will not exceed about 6 inches and may be somewhat less, the amount less than these figures probably depending upon the rainfall for one, two, or three years previous.

In reference to the construction of these curves, it may be remarked that if for any given stream, where reliable precipitation and run-off data are available, we arrange the yearly quantities in the order of the magnitude of the rainfalls and without reference to sequence of years, as per the following tabulations, we find that there is a clear relation between the rainfall in any given year and the run-off of that year. By plotting the precipitation as abscissas and the run-offs as ordinates we may construct what may be termed the run-off curve of any given stream. On drawing such a curve we find that the run-offs for given precipitation will group themselves above and below the curve, the extent of the departures from a true curve depending upon the accuracy of the data. If there are wide variations, we may conclude that there are large errors either in the rainfalls or run-offs, or both. If, on the contrary, the points all fall very nearly in the curve, we are justified in assuming the essential accuracy of the data. Judged by this standard the precipitation and run-off data of Hudson and Genesee rivers are exceedingly accurate. Indeed they give, so far as the author is aware, more nearly the true values than any extended set of gaugings from such large areas thus far made. The following are the precipitations and run-offs for Hudson River for the eleven years from 1888 to 1898, inclusive, arranged in the order of the magnitude of the rainfalls:

HUDSON RIVER.

Year.	Rainfall. inches.	Run-off. inches.	Year.	Rainfall, inches.	Run-off, inches.
1892	53.87	33.08	1891	42.96	20.56
1890	50.35	28.56	1889	*a* 42.96	21.71
1898	48.30	27.65	1893	42.18	21.91
1897	46.51	26.19	1894	41.37	19.87
1896	45.21	23.65	1895	38.67	17.46
1888	43.92	23.64			

a Probably 42.96 inches rainfall for 1889 is only approximately correct. Data incomplete.

For Genesee River these data take the following form:

GENESEE RIVER.

Year.	Rainfall, inches.	Run-off, inches.	Year.	Rainfall, inches.	Run-off, inches.
1894	47.79	19.38	1893	39.30	13.35
1890	47.54	21.22	1891	38.12	14.05
1898	42.50	15.18	1897	34.89	9.38
1892	41.69	15.42	1895	31.00	6.67
1896	40.68	13.35			

The comparison of these two series shows that Hudson River data are somewhat better than Genesee. The reasons for this have been partially given in a lecture on the data of stream flow in relation to forests before the engineering classes of Cornell University, April 14, 1899, and printed in the Transactions of the Association of Civil Engineers of Cornell University for 1899. There is, however, another reason why these figures are more accurate than such data usually are. In the first place, the rainfalls have for both catchment areas been deduced from the means of a number of stations, whereas it is still a very common practice to take the rainfall of one or two stations as representing the mean of the whole. For large catchment areas this almost invariably gives results wide of the truth. Again, the stream gaugings on Hudson and Genesee rivers are more nearly true than such data usually are. On Hudson River the use of the formula of the Indian engineers has given results which are approximately true, while on Genesee River the original data, as taken from the timber dam of the Mount Morris Hydraulic Power Company, have been reduced to weir measurement by the actual construction of a wier and the rating of the gauging dam, as detailed elsewhere. In view of these facts it is the author's opinion, after examining nearly all the gaugings made in the United States, that the figures for these two streams are considerably more accurate than such data usually are.

In order to show how necessary it is to hold the excess storage of Black and Salmon rivers reservoirs to cover the contingency of some extremely dry year in which the precipitation does not much exceed 30 inches, and in which year, consequently, the run-off will probably not exceed about 10 inches, we will go into a somewhat extended analysis of Tables Nos. 20 to 118, inclusive, the object being to show that in the State of New York there have been years when for the entire State the rainfall has not exceeded about 30 inches. What has happened once is likely to happen again.

At Albany (Table No. 22) the water years 1895 and 1896 represented a period of very low precipitation. The following are the figures for the several periods:

	1895.	1896.
Storage	12.58	14.79
Growing	8.88	8.31
Replenishing	8.93	6.64
Total	30.39	29.74

The total precipitation of the previous year, 1894, was 34.45 inches. It is probable that for the water year 1896 streams in the vicinity of Albany did not run to exceed 9 inches on the catchment area.

At Auburn (Table No. 26) the years 1836, 1837, and 1838 cover a period of very low precipitation, as shown by the following:

	1836.	1837.	1838.
Storage	19.41	10.37	7.50
Growing	6.39	11.35	8.14
Replenishing	6.56	6.78	6.05
Total	32.36	28.50	21.69

Taking into account the sequence of the foregoing record at Auburn, it is probable that in the water year 1838 the run-off of streams in that vicinity did not exceed 3 to 4 inches on the catchment area.

In view of its relations to run-off of Upper Hudson catchment area we may refer to the record at Burlington, Vt. (Table No. 34), for the years 1893 to 1896, inclusive. We have the following from the Burlington record:

	1893.	1894.	1895.	1896.
Storage	8.33	10.35	10.70	9.70
Growing	13.78	4.51	10.08	11.05
Replenishing	5.25	8.34	8.19	8.55
Total	27.30	23.20	28.97	29.30

Taking into account the low precipitation of 1894, it is probable that in 1895 and 1896 streams in the vicinity of Burlington did not run to exceed 5 to 6 inches on the catchment area.

At Cazenovia (Table No. 38) the two lowest consecutive years are 1834 and 1835, when the total run-offs were 34.29 inches in 1834 and 32.82 inches in 1835. Inasmuch as streams in that vicinity fall in the same category as Genesee River, if we assume similar conditions of forestation, the run-off was probably about 8 inches on the catchment area.

At Cooperstown (Table No. 42) the mean precipitation for the entire period covered from 1854 to 1898, inclusive, is 39.07 inches. The three consecutive minimum years occurred from 1879 to 1881, inclusive. The following are the precipitations for those years:

	1879.	1880.	1881.
Storage	14.91	18.57	12.33
Growing	8.44	10.05	7.38
Replenishing	6.38	8.61	9.56
Total	29.73	37.23	29.27

In 1881 the run-off of streams in the vicinity of Cooperstown probably did not exceed 7 inches.

The Cooperstown record is considered one of the best long records in the State.

At Geneva (Table No. 51) the mean precipitation for twenty-five years, between 1850 and 1893, inclusive, is 30.86. In the period from 1883 to 1888, inclusive, the precipitation at Geneva was continuously below the mean, as indicated by the following tabulation:

	1883.	1884.	1885.	1886.	1887.	1888.
Storage	9.38	10.43	5.61	10.02	6.70	10.48
Growing	10.57	5.78	12.15	10.19	11.41	8.89
Replenishing	5.76	5.85	6.35	7.18	4.07	8.22
Total	25.71	22.06	24.11	27.39	22.18	27.59

For the years 1887 and 1888 it is probable that streams in the vicinity of Geneva did not flow to much exceed 2 to 4 inches on the catchment area.

At Glens Falls (Table No. 52) the mean precipitation for the years 1879 to 1898, inclusive, is 37.76 inches. The following is the record for the years 1880 to 1884, inclusive:

	1880.	1881.	1882.	1883.	1884.
Storage	14.73	14.83	15.35	13.07	15.97
Growing	4.61	5.15	9.37	5.01	7.31
Replenishing	10.38	8.08	6.19	10.11	6.37
Total	29.72	28.06	31.21	28.19	29.65

A study of run-off records shows that the precipitation of the storage period largely controls the run-off for the year; hence in a year like 1883, when the precipitation of the storage period was only 13.07 inches, especially when such a year has been preceded by years like 1880 to 1882, inclusive, the run-off will certainly be very low. Probably in 1883 it did not exceed, in the vicinity of Glens Falls, about 6 inches. In 1884 the precipitation of the storage period was 2.90 inches greater than in the previous year, but this small additional precipitation was probably mostly without effect on the streams because of low-ground water. It appears, therefore, entirely safe to assume that the run-off of streams in the vicinity of Glens Falls must have been quite as low in 1884 as in the previous year 1883.

At Gouverneur (Table No. 54) the total precipitation of the year 1838 was 20.93 inches; of 1839, 18.87 inches, and 1842, 17.06 inches. Assuming forestry conditions at that time in the vicinity of Gouverneur substantially as they now exist on Hudson River catchment area, the run-off of the streams may have been 3 inches, or from deforested areas probably 2 inches.

At Ithaca (Table No. 61) the two lowest years of precipitation are 1884 and 1895, in both of which the total happens to be 26.98 inches. In 1846 the total of the storage period was 9.67 inches, the total for the year being 30.07 inches. It is probable that the extreme minimum run-off in the vicinity of Ithaca does not exceed 5 inches.

At Keene Valley (Table No. 63) the lowest precipitation occurred in 1881, the total for that year being 28.20 inches. The precipitation of the storage period was 13.15 inches. The totals of the previous years, 1879 and 1880, were 32.15 and 33.32, respectively. The run-off for 1881 probably did not exceed 8.9 inches.

At Lowville (Table No. 69) the period of lowest precipitation was for the years 1843 to 1846, inclusive. The following are the figures for those years:

	1843.	1844.	1845.	1846.
Storage	7.06	11.53	12.90	9.76
Growing	12.12	7.64	8.30	5.78
Replenishing	8.30	7.34	9.60	11.63
Total	27.48	26.51	30.80	27.17

A marked peculiarity of this Lowville period is the low precipitation of the storage period for all the years included. Taking this into account, it is probable that for the years 1845 and 1846 the run-off in the vicinity of Lowville was very low. In 1845 it may have reached 8 inches, but for 1846 it is doubtful if it exceeded 5 or 6 inches. These conclusions, it must be understood, are based on present conditions of forestation. In case there were much larger forest areas in that vicinity at that time, the run-offs may have been somewhat larger.

At Mexico (Table No. 72) the total precipitation for the year 1840 was 20.21 inches, the storage period of that year being 9.73 inches. The run-off probably did not exceed 2 inches.

At Mount Morris (Table No. 76) the total precipitation of the year 1891 was 23.69 inches, that of the storage period being 10.24 inches. In 1895 the total was 25.05 inches, the storage period giving 11.95 inches. From the author's personal knowledge of the subject he has no hesitation in saying that in 1895 streams in the vicinity of Mount Morris did not exceed a total run-off of about 3 to 4 inches.

The year 1895 was generally a year of low precipitation throughout the whole State. Thus, at Newark Valley (Table No. 77) the total was 28.40; at New Lisbon (Table No. 78) the total was 29.93; at North Hammond (Table No. 79) the total was 29.80, and so on. An extended analysis of these precipitation tables shows that for a large portion of the State of New York the run-off of 1895 did not exceed 6 to 12 inches on the catchment areas. At some places the run-offs were less than 6 inches.

At Onondaga Hollow (Table No. 83) the year of minimum precipitation occurred in 1841, having been preceded by several years of rather low rainfall. Streams in that vicinity probably do not exceed 6 inches run-off in years of minimum precipitation.

At Oswego (Table No. 84) precipitation sank to 26.15 inches in 1855 and to 23.46 inches in 1887; in 1889 it was 30.39 inches. In 1887 the total for the storage period was 10.55 inches. It is doubtful if the run-off at Oswego exceeded about 2 to 4 inches for that year.

At Oxford (Table No. 85) we have the following record for the years 1832 to 1834, inclusive.

	1832.	1833.	1834.
Storage	13.72	14.65	9.62
Growing	8.71	9.61	11.75
Replenishing	5.64	10.69	6.99
Total	28.07	34.95	28.36

The low precipitation of the storage period of the water year 1834 indicates run-offs in the vicinity of Oxford for that year of perhaps 5 inches.

At Palermo (Table No. 86), where we have a continuous record from 1854 to 1898, inclusive, there are several years in which the precipitation is given considerably below 30 inches, as, for instance, in 1871, 27.81 inches; 1875, 28.11 inches; 1881, 26.37 inches; 1882, 28.86 inches, and in 1895, 25.97 inches. The precipitation of the storage period of 1895 was only 10.15 inches. It is probable that for that year streams in the vicinity of Palermo did not exceed a run-off of about 2 inches.

At Pen Yan (Table No. 87) we have a continuous record from 1829 to 1867, inclusive, the mean of the whole period being 27.93 inches. There are several periods of from three to six years when the rainfall was less than the average. So marked is this that it seems safe to assume that streams in the vicinity of Pen Yan do not ordinarily run more than from 4 to 6 inches on the catchment area. In 1854 the total precipitation was 19.66 inches. There are several years in which the total precipitation at Pen Yan for the storage period has not exceeded from 8 to 9 inches.

At Pierpont Manor (Table No. 90) the totals for the years 1852 to 1854 are as follows: 1852, 30.93; 1853, 27.57, and for 1854, 28.89 inches. In 1862 the total precipitation was 28.15 inches.

At Plattsburg (Table No. 91) the total precipitation in 1858 was 29.11 inches, and in 1859, 22.78 inches. In 1893 it was 25.69 inches, with a total of only 9.92 inches in the storage period. For 1895 the total was 29.75 inches. It is evident that the minimum run-off of streams in the vicinity of Plattsburg does not exceed 6 inches.

At Pompey (Table No. 92) the totals for the years 1836 to 1838 are as follows: For 1836, 24.22 inches; 1837, 28.37 inches, and 1838, 24.82 inches.

At Port Ontario (Table No. 93) the total precipitation for 1855 was 26.15 inches; for 1871, 29.76 inches, and for 1872, 28.81 inches.

At Potsdam (Table No. 94) we have the following record for the years 1837 to 1839, inclusive:

	1837.	1838.	1839.
Storage	10.70	10.19	7.75
Growing	7.91	9.57	10.20
Replenishing	9.63	7.44	4.67
Total	28.24	27.20	22.62

In 1895 the total precipitation at Potsdam was 31.83 inches.

At Poughkeepsie (Table No. 95) the total for the year 1895 was 31.53 inches.

At Rochester (Table No. 97) we have a continuous record from 1834 to 1898, inclusive. The mean precipitation for this whole period is 33.61 inches. For the period from 1834 to 1840, inclusive, the total for each water year is considerably under the mean, as follows: In 1834, 20.37 inches; 1835, 28.67 inches; 1836, 26.83 inches; 1837, 29.57 inches; 1838, 27.02 inches; 1839, 29.97 inches, and in 1840, 28.64 inches. In 1854 the total was 28.06 inches; in 1882 it was 26.74 inches; in 1885, 28.68 inches, and in 1887 only 20.61 inches. In 1888 the total rose to 27.34 inches, but the precipitation of the storage period was only 9.65 inches. It is probable that the run-off of streams in 1888 in the vicinity of Rochester did not exceed 3 to 4 inches. In 1895 the total at Rochester was 30.15 inches.

At Rome (Table No. 98) the year of minimum precipitation for the period from 1890 to 1898, inclusive, was 1895, in which year the total of the storage period was 13.57 inches, and the total for the year, 31.30 inches.

At Romulus (Table No. 99) the total for the storage period was 10.87, the total for the year being 27.76 inches.

At Rutland (Table No. 101) the period 1854 to 1856 covered years of low precipitation. The mean at that place from 1846 to 1861, inclusive, is 36.54 inches, but the total for 1854 was only 29.50; for 1855, 32.07, and for 1856, 28.83 inches. In 1856 the run-off of streams in the vicinity of Rutland could not have exceeded about 5 inches.

At Sacketts Harbor (Table No. 102) the mean from 1864 to 1898, with four years omitted, is 32.50 inches. The period 1870 to 1876, inclusive, was far below the mean, the totals being as follows: 1870, 25.16 inches; 1871, 26.62 inches; 1872, 30.75 inches; 1873, 28.79 inches; 1874, 27.58 inches; 1875, 22.30 inches; and 1876, 25.42 inches. In 1875 the total precipitation of the storage period was 8.63 inches. The total run-off of that year in the vicinity of Sacketts Harbor could not have much exceeded about 2 inches.

The years 1879 to 1888 were also low years at Sacketts Harbor. The following gives the record for 1886 to 1888:

	1886.	1887.	1888.
Storage	14.64	11.10	4.24
Growing	7.38	4.10	5.92
Replenishing	8.82	7.96	14.59
Total	30.84	23.16	24.75

These three years were preceded by several years in which the precipitation ranged from 22.50 inches to 28.87 inches, the year 1885 having shown a total of 26.83 inches. For the year 1895 the total at Sacketts Harbor was 29.39 inches.

At South Canisteo (Table No. 106) the total for the year 1895 was 30.72 inches.

At Utica (Table No. 112) the mean of thirty-six years, included between 1826 and 1892, is 42.39 inches. The lowest year of this period was 1836, with a total of 31.75 inches.

At Watertown (Table No. 114) the mean of the period from 1862 to 1898, inclusive, is 33.53 inches. Table No. 114 shows several short periods in which the precipitation has been far below the mean, as, for instance, from 1874 to 1876, inclusive; from 1879 to 1882, inclusive, and in the years 1887 and 1888. In 1875 the run-off of the storage period was 9.82 inches, the total for the year being 21.16 inches. The preceding remarks as to occasional very low run-off apply with force to conditions in the vicinity of Watertown. The minimum run-offs of the locality may be safely placed at from 4 to 6 inches.

At Waverly (Table No. 115) the total precipitation of the year 1895 was 25.10 inches.

At Williamstown, Mass. (Table No. 118), in the catchment area of Hoosick River, a tributary to Hudson, the precipitation record covers certain years from 1855 to 1898, inclusive. The mean of the period is 39.41 inches. The year of minimum precipitation occurred in 1883, with a total of 29.55 inches for the year and 11.24 inches for the storage period.

The foregoing data of precipitation in the State of New York are cited for the purpose of establishing the proposition that at times the run-offs of New York streams are very low, and that consequently the reserve storage of Black River reservoir is none too large. Undoubtedly the saving grace of the whole matter is that apparently the cycles of low precipitation do not affect the whole State at the same time. Indeed, it is only occasionally that catchment areas as large as Upper Hudson, Black, Mohawk, Oswego, and Genesee rivers will be all subject to drought in the same year. A balancing of conditions is thus to some extent brought about. Nevertheless, while the preceding statement is fairly deducible from the data, it is the author's opinion that if we had complete records it would be easily shown that the rainfall of nearly the entire State has in some year been on an average less than 30 inches, and that consequently the streams of the State, as a whole, did not average in such a year a run-off of more than about 7 to 10 inches. For individual catchment areas, like Upper Genesee, where the total is 1,070 square miles, or for Oneida Lake area, with a total above Brewerton of 1,265 square miles, it is quite possible, and indeed probable, that the minimums affecting the whole area may sink somewhat lower. Probably 25 inches precipitation is not an unreasonable figure. If such a minimum should occur for Oneida Lake area the run-off for the water year would not exceed about 5 inches. Should this happen Oneida Lake would not by itself furnish an adequate water supply for a low level canal in the Oswego-Mohawk Valley. For high level canals, as already stated, the reserve storage of Black River reservoir will be sufficient to meet the conditions of the most adverse year.

In order to verify run-off diagrams of plate 139, reference may be made to tables showing the mean precipitation of Hudson River catchment area in the author's second report on Hudson River storage in the Annual Report of the State Engineer and Surveyor of New York for 1896. Tables showing the mean precipitation of Genesee River catchment area may also be found in the author's report on Genesee River storage in the Annual Report of the State Engineer and Surveyor for 1896.

FLOOD FLOWS OF STREAMS IN THE STATE OF NEW YORK.

Table No. 124 gives maximum and ordinary flood flows of a number of streams in the State of New York. The statements therein given represent the best information at hand, but it is probable that some of them might be modified by more extended data. It is not believed, however, that the modifications would be of such extent as to specially vitiate any conclusions which may be drawn from these data.

TABLE No. 134.—*Showing maximum and ordinary flood flows of streams in the State of New York.*

Serial number.	Stream.	Location of dam.	Catchment area above dam (in square miles).	Depth on crest of dam.			Length of crest of dam (in feet).	Total discharge over dam (cubic feet per second).		Leakage of dam and water used on wheels (cubic feet per second).	Cubic feet per second.		Total flow of stream (cubic feet per square mile per second).		Remarks.
				Maximum head (in feet).	Reported date of occurrence of flood.	Ordinary spring flood head (in feet).		Maximum reported.	Ordinary spring flood.		Maximum reported equals sum of columns (9) and (11).	Ordinary spring flood equals sum of columns (10) and (11).	Maximum reported.	Ordinary spring flood.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1	Seneca River	Baldwinsville	3,103.0	4.75	Mar., 1865	3.00	423.0	12,200	6,218	7,750	19,950	13,968	6.4	4.5	
2	Oswego River	Fulton	4,915.6	4.00		3.00	404.6	10,800	7,000	8,700	19,500	15,700	4.0	3.2	
3	Chittenango Creek	Bridgeport	306.9	3.00	1896	1.50	214.7	4,030	1,350	75	4,105	1,425	13.3	4.6	
4	Oneida Creek	Kenwood	59.0	5.00	1890	2.50	79.4	3,292	1,150	None.	3,292	1,150	41.2	11.7	
5	Wood Creek	Fish Creek	126.5	8.00	Spring, 1895	7.00		2,630	2,270	None.	2,630	2,270	20.8	18.0	
6	West Branch Fish Creek.	McConnellsville	186.7	4.00	1884	3.00	176.0	6,100	3,350	70	6,170	3,420	32.7	18.4	
7	East Branch Fish Creek.	Point Rock	104.3	7.00	Fall, 1897	4.00	173.7	8,400	3,850	None.	8,400	3,850	80.5	36.9	
8	Salmon River	1 mile above falls	190.5	4.00	Summer, 1888	3.00	228.6	5,670	3,580	None.	5,670	3,580	29.7	18.8	
9	Mohawk River	Ridge Mills	152.5	5.00	Spring, 1888	4.00	122.7	7,030	3,040	50	7,080	3,090	46.4	20.3	
9a	do	do	152.5	4.75	Mar. 12, 1898		122.7	5,266			5,266		34.5		Deduced from gaugings by Mr. Harrison.
10	Nine Mile Creek	Stittville	62.6	5.00	Aug. 25, 1898	2.00	176.7	7,820	1,890		7,820	1,890	124.9	31.9	
10a	do	do	62.6	1.94	Mar. 12, 1898		176.7	1,800			1,800		28.7		Do.
11	Oriskany Creek	Oriskany	144.3	5.00	Spring, 1896	2.50	214.0	7,500	2,560	10	7,510	2,570	52.7	17.8	
11a	do	do	144.3	1.03	Mar. 12, 1898		214.0	890		10	900		6.2		Do.
12	do	Colmans	140.7	4.50	Spring, 1888	2.50	180.5	7,800	2,957	30	7,830	2,990	55.8	21.3	
13	Sauquoit Creek	New York Mills	51.5	8.00		2.00	141.0	2,700	1,470	50	2,750	1,520	53.4	29.5	
14	West Canada Creek	Middleville	518.7	5.50	Aug., 1898	4.00	330.5	12,250	6,900	700	12,950	7,600	24.9	14.6	
14a	do	do	518.7	2.85	Mar. 20, 1898		330.5	3,660		700	4,360		8.4		Do.
15	Mohawk River	Little Falls	1,306.0	10.50	1890	6.00	181.7	21,600	9,300	400	22,000	9,700	16.9	7.4	This is not the same dam as 15a.
15a	do	do	1,306.0	6.72	Mar. 14, 1898		337.0	20,920		2,829	23,749		18.2		Deduced from gaugings by Mr. Harrison.
16	East Canada Creek	Dolgeville	255.6	5.00	Aug. 25, 1898	3.50	190.25	6,300	3,460	25	6,325	3,485	24.7	13.6	
17	Garoga Creek	4 miles above Fort Plain.	80.8	2.00	Fall and spring	2.00	118.85	1,280	1,280		1,280	1,280	15.8	15.8	

18	Cayadutta Creek	Johnstown	40.0	3.50	1898	2.00	158.9	2,870	1,240	25	2,895	1,265	72.4	31.4	
19	Schoharie Creek	Fort Hunter	946.7	8.00	1892	6.00	586.4	41,300	26,600	415	41,715	27,015	44.0	28.5	
20	Mohawk River	Rexford Flats	3,384.9	10.00	1892	8.00	675.0	78,300	48,100	50	78,350	48,150	23.1	11.2	
21	Hudson River	Mechanicville	4,500.0	8.30	Apr. 19, 1896	......	794.0	59,400	40,000	....	59,400	40,000	13.2	8.9	
21a	do	do	4,500.0	......	Spring, 1869	......	794.0	70,000	....	....	70,000	....	15.5	......	
21b	do	Fort Edward	2,825.0	8.16	Apr. 18, 1895	5.25	587.0	41,675	22,500	4,000	41,675	26,000	14.7	9.2	
	West Branch Fish Creek:														
22	Williamstown *b*	Upper Dam	16.2	4.00	....	2.50	19.0	400	185	100	500	285	30.9	17.6	
23	Williamstown *b*	Lower Dam	16.5	3.00	....	......	27.0	486	....	75	561	....	34.0	......	
24	West Camden	Mott's Dam	47.5	4.50	Spring, 1884	3.00	57.0	1,470	769	150	1,620	919	34.1	19.3	
25	Camden *c*	Grist Mill Dam	61.4	2.50	June, 1889	1.50	96.0	1,325	616	150	1,475	766	24.1	12.4	
26	Camden *c*	Foundry Dam	61.5	2.34	....	1.67	99.0	1,267	812	150	1,417	962	23.0	15.6	
27	Camden *c*	Planing Dam	61.5	2.34	....	1.33	102.0	1,306	612	150	1,456	762	23.5	12.4	
28	Camden *c*	Dorance's Dam	68.8	1.79	....	1.00	50.0	445	205	890	1,335	1,095	21.9	18.0	
29	Fish Creek *d*	Fish Creek	533.0	......	Mar. 15, 1898	......	....	7,597	....	None.	7,597	....	14.2	......	Below confluence of Wood and Fish creeks.
30	do. *d*	Taberg Station	387.0	......	Mar. 14, 1898	......	....	5,875	....	None.	5,875	....	15.2	......	Below confluence of East and West branches Wood and Fish creeks.
31	Mad River *e*	Camden	46.5	2.15	....	1.16	79.5	922	350	....	922	350	19.9	7.5	Conant's Dam.
32	do *e*	do	46.6	1.76	....	1.00	130.0	780	150	250	1,030	400	22.1	8.6	Grist Mill Dam.
33	North Branch Sandy Creek.	Adams	110.0	4.83	Winter, 1897	3.00	190.0	7,410	3,610	....	7,410	3,610	67.3	32.8	Foundry Dam below Main street.
33a	South Branch Sandy Creek.	do	110.0	5.50	Dec., 1898	......	80.0	3,840	....	....	3,840	......	35.0	......	Grist Mill Dam above Main street.
34	do	Allendale	68.4	5.50	1890 or 1891	3.00	170.0	6,000	2,375	....	6,000	2,375	87.7	34.7	
35	Skinner Creek	Mannsville	6.4	4.00	Summer, 1891	1.67	32.0	795	224	....	795	224	124.2	35.0	
36	Trout Brook	Centerville	23.0	3.00	....	2.00	60.0	1,146	621	20	1,166	641	50.6	28.0	
37	Salmon River	Altmar	220.7	2.50	....	1.85	380.0	5,550	3,496	550	6,100	4,045	27.6	18.3	
38	Beaver Dam Creek	do	20.7	2.50	....	1.00	112.3	2,299	407	....	2,299	407	111.0	20.0	
39	Woodhull Creek	Hill Tannery	108.4	2.30	Apr., 1869	1.80	*f* 275.0	4,040	2,310	....	4,040	2,310	37.4	21.3	
40	Moose River	Ager's Paper Mill.	407.3	6.43	do	5.15	209.0	12,644	9,050	....	12,644	9,050	31.0	22.2	
41	Otter Creek	Casler's Paper Mill.	63.0	2.69	do	1.60	120.0	1,944	936	....	1,944	936	30.9	14.9	
42	Independence Creek. *g*	Crandal's Paper Mill.	93.2	4.13	do	2.38	200.0	6,200	2,660	....	6,200	2,660	66.5	28.5	
43	Beaver River	Beaver Falls	322.3	5.00	do	3.50	130.0	5,382	3,146	....	5,382	3,146	16.7	9.7	
44	Deer River	Deer River	100.8	6.47	do	3.66	*h* 123.0	7,881	3,173	....	7,881	3,173	78.1	31.4	

a Serial Nos. 1 to 21 (inclusive) designate gauging stations. Depths on crest, as per columns 5 and 7, are above gauge zeros.

b Mean in column (14) equals 32.5.

c Mean in column (14) equals 23.1; in column (15), 14.4.

d Nos. 29 and 30 are from gaugings by Mr. Harrison.

e Mean in column (14) equals 21.

f An additional length of 50 feet under 2-foot head in April, 1869.

g Deduced from exhibit by L. L. Nichols, Black River Water Claims, Vol. I, page 640. Columns (5), (6), (8), (12), and (14) relate to the great flood of 1869. Columns (7), (9), (13), and (15) show the highest water known prior to the great flood of April, 1869.

h An additional length equivalent to 26 feet under 2.40-foot head in April, 1869.

TABLE No. 124.—*Showing maximum and ordinary flood flows of streams in the State of New York*—Continued.

Serial number.	Stream.	Location of dam.	Catchment area above dam (in square miles).	Depth on crest of dam.			Length of crest of dam (in feet).	Total discharge over dam (cubic feet per second).		Leakage of dam and water used on wheels (cubic feet per second).	Cubic feet per second.		Total flow of stream (cubic feet per square mile per second).		Remarks.
				Maximum head (in feet).	Reported date of occurrence of flood.	Ordinary spring flood head (in feet).		Maximum reported.	Ordinary spring flood.		Maximum reported equals sum of columns (9) and (11).	Ordinary spring flood equals sum of columns (10) and (11).	Maximum reported.	Ordinary spring flood.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
45	Black River	Forestport	298.0		1850			10,450			10,450		39.0		
46	do	Lyons Falls	878.5	7.80	Apr., 1869	4.95	500.0	40,400	20,400		40,400	20,400	46.0	23.2	
47	do	Carthage	1,812.2	5.14 2.14	do	4.70 1.70	886.0 110.0	39,529	35,360		39,529	35,360	21.2	19.5	
48	do	4 miles below Carthage.	1,824.1	10.57	do	7.29	*a* 273.0	39,009	21,017		39,009	21,017	21.3	11.5	
49	do	Below Black River.	1,868.9	9.85	do		*a* 250.0	39,137			39,137		20.9		
50	do	Watertown	1,891.7	9.00	do		*a* 279.0	39,606			39,606		20.9		
51	do	Ontario Paper Mill.	1,903.3	12.00	Apr., 1896		183.0	28,222		115	28,337		14.8		
52	do	Huntingdonville Dam.	1,889.0	6.00	Mar., 1898	5.00	606.0	27,700	20,350	200	27,900	20,550	14.8	10.9	
53	Croton River	Croton Dam *b*	338.8					25,376			25,376		74.9		
54	Genesee River	Rochester	2,365.0		Mar. 19, 1865			40,000	20,000		40,000	20,000	17.0	8.5	
55	do	do	2,365.0		June 1, 1889			27,000			27,000		11.4		
56	do	Mount Morris	1,070.0		May 2, 1894			42,000	30,000		42,000	30,000	39.2	28.0	
57	Chemung River	Elmira	2,055.0		June 1, 1889			138,000			138,000		67.1		Francis Collingwood, authority.

a Depth and length for main section of dam only are here given.
b J. J. R. Croes, authority.

Taking up the streams in the order of the serial numbers of the table, explanatory matter relating to each will be presented.

(1) SENECA RIVER.

Gauging station No. 1 was established on this stream at Baldwinsville in November, 1897. According to statements made by people at Baldwinsville, mill owners and others, ordinary high water is about 3 feet on the crest and occurs nearly every spring. This gives a discharge over the present dam and through the water wheels of 13,968 cubic feet per second. In 1865, which was a year of unusually high floods in central and western New York, it is stated that the water went higher than this, but no person has been found thus far who is able to give the exact height. We will show why this stream, with 3,103 square miles of catchment area, gives so small a flood flow in the following discussion of the Oswego River.

All statements agree that floods seldom occur in the fall of the year on Seneca River.

(2) OSWEGO RIVER.

A gauging station was established on Oswego River at Fulton in November, 1898, the catchment area above the point of gauging being 4,915.6 square miles. The highest water reported is a depth of 4 feet on the crest of the dam at Fulton, the flow being 19,500 cubic feet per second, the ordinary spring flood amounting to 17,700 cubic feet per second. This figure is substantially verified by the statement of the late Charles Rhodes, esq., of the Oswego Canal Company, who studied Oswego River extensively and who, according to the report on water power of the United States of the Tenth Census, claimed that the ordinary flood discharge at Oswego was from 16,000 to 17,000 cubic feet per second and that an excessive flood might be as large as 41,000 to 42,000 cubic feet per second, these latter figures probably being the discharge of the Oswego River in the great flood of March, 1865. Thus far, however, exact figures have not been obtained of any flood exceeding about 20,000 cubic feet per second, as per column (12) of Table No. 124. As will be seen from column (14) of the table, these flows, when computed in cubic feet per square mile per second, do not exceed 4 cubic feet, which is very small.

The catchment area of the Oswego River at Oswego is 5,002 square miles, and a very interesting question arises as to why a stream with so large an area as this, issuing from a region with a mean annual rainfall of from about 30 to 40 inches and with heavy snow falls, frequently melting suddenly at the end of winter, should not show greater flood flows than a maximum of about 4 cubic feet per square mile per second. The answer may be found in considering the large temporary storage on the surfaces of the lakes, marshes, and flat valleys of Oswego basin. By way of showing this saliently, we have prepared the following table, in which appear the names of the several lakes, with their approximate catchment areas, areas of water surface, areas of flats and marsh, and total area of water surface, flats, and marsh. The table is self-explanatory, and attention is merely directed to the footings, from which it appears that the total area of water surface is, approximately, 309.3 square miles, the total area of flats and marsh 220.7 square miles, and the total of water surface, flats, and marsh 530 square miles.

Pondage areas in Oswego River basin.

(1) SENECA BASIN.

Name of lake or river.	Catchment area.	Area of water surface.	Area of flats and marsh.	Total area of water surface, flats, and marsh.
	Sq. miles.	*Sq. miles.*	*Sq. miles.*	*Sq. miles.*
Canandaigua	175.0	18.6	8.0	26.6
Keuka	187.0	20.3	3.0	23.3
Seneca	707.0	66.0	4.0	70.0
Cayuga	1,593.0	66.8	2.0	68.8
Owasco	208.0	12.4	5.5	17.9
Skaneateles	73.0	12.8	0.5	13.3
Otisco	34.0	3.0	0.5	3.5
Cross	(*a*)	4.3	(*b*)	4.3
Onondaga	233.0	4.0	0.5	4.5
Seneca River	233.0	3.5	(*b*)	3.5
Montezuma Marsh			45.0	45.0
Miscellaneous small ponds		3.5		3.5
Miscellaneous flat valleys			20.0	20.0
Total	3,433.0	215.2	89.0	304.2

(2) ONEIDA BASIN.

Name of lake or river.	Catchment area.	Area of water surface.	Area of flats and marsh.	Total area of water surface, flats, and marsh.
Cazenovia	9.0	2.8	0.3	3.1
Oneida	1,265.0	80.0	120.0	200.0
Miscellaneous small ponds		5.9		5.9
Miscellaneous flat valleys			6.0	6.0
Oneida River	128.0	0.9	2.1	3.0
Total	4,835.0	304.8	217.4	522.2

(3) OSWEGO BASIN

Name of lake or river.	Catchment area.	Area of water surface.	Area of flats and marsh.	Total area of water surface, flats, and marsh.
Miscellaneous small ponds		2.5		2.5
Oswego River	167.0	2.0	3.3	5.3
Total	5,002.0	309.3	220.7	530.0

a Enlargement of Seneca River. *b* Area of flats and marsh included in Montezuma Marsh.

Dividing the total area of water surface, flats, and marsh of 530 square miles by 5,002, the area of the catchment basin, it appears that the total area of water surface, flats, and marsh is 10.6 per cent of the whole. We do not often have flood run-offs in New York State exceeding 3 or 4 inches in depth over the catchment area, but 4 inches in depth over the Oswego area would be only 37.7 inches on the pondage area of 530 square miles.

Several of the large lakes of this basin fluctuate considerably between high and low water. From tabulations given in the report of the superintendent of public works it is shown that the fluctuation on

Skaneateles Lake, which is drawn upon as a canal reservoir, is as much as 5 feet, and on Otisco Lake about 4.5 feet. According to figures given in the Eleventh Annual Report of the State Board of Health of New York, page 520, it appears that the maximum fluctuation of Cayuga Lake for a long series of years has been 7.56 feet, although this large fluctuation may be possibly partly due to work done by the State in cutting out the channel of Seneca River for the purpose of draining the Montezuma Marsh. Ordinarily the fluctuation of Cayuga Lake does not exceed between 2 and 3 feet. Thus, from March 4, 1887, to December 2 of that year the lake fell 2.93 feet, and from March, 1889, to December of that year the fluctuation was 2.3 feet. The figures are not at hand giving the fluctuation of Canandaigua, Keuka, Seneca, and the other large lakes of this basin, but it may be certainly assumed that they do not vary greatly from the preceding figures of Skaneateles, Otisco, and Cayuga lakes. By way of illustrating how these great natural reservoirs tend to prevent floods, it may be mentioned that the configuration of Cayuga outlet with relation to Clyde River is such that frequently, when there are heavy rainfalls in the catchment area of Clyde River, Cayuga Lake being at the same time at a low level, the entire flood flow of Clyde River is discharged into Cayuga Lake without affecting Seneca River below the mouth of Clyde River at all. It is undoubtedly due to this fact that fall floods on Oswego River are almost entirely unknown.

In a litigation in 1875, in the case of Michael J. Cummings against owners and lessees of water on Varick Canal at Oswego, it was assumed by the court in the decision that the extreme low-water flow, which is stated to usually occur in the months of July or August, is about 1,170 cubic feet per second, or 0.21 of a cubic foot per square mile per second. This is evidently meant for a few days only, as the same decision recites that the low-water summer flow is from 1,500 to 1,670 cubic feet per second, or from about 0.3 of a cubic foot per square mile per second to 0.312 cubic foot. It is probable, however, in view of the large evaporation of this basin, that the low-water flow may be, in some year of extreme minimum rainfall, somewhat lower than this.

(3) CHITTENANGO CREEK.

This stream has a catchment area of 306.9 square miles above the gauging station at Bridgeport. It is tributary to Oneida Lake, and, like many of the Oneida Lake tributaries, has considerable flat area. The extreme flood is taken at 4,105 cubic feet per second, or 13.3 cubic feet per square mile per second.

(4) ONEIDA CREEK.

Kenwood, the point of gauging on this stream, is pretty well up from Oneida Lake, of which the Oneida Creek is a tributary. This stream has a rapid descent from the hills above the point of gauging, where the catchment area is only 59 square miles, and shows a maximum flood of about 41.2 cubic feet per square mile per second, with ordinary spring floods of 14.7 cubic feet per square mile per second.

(5) WOOD CREEK.

This stream has 126.5 square miles of catchment area above the point of gauging, mostly flat, level country. The highest flood reported was in the spring of 1895, when the maximum run-off was 20.8 cubic feet per square mile per second.

(6) WEST BRANCH OF FISH CREEK.

The catchment area of this stream above McConnellsville, the point of gauging, is 186.7 square miles. The swamp and marsh area of this stream is large enough to distribute the flood flows, thus keeping the maximum, which is reported as having occurred in 1884, down to 6,170 cubic feet per second, or about 33 cubic feet per square mile per second. The ordinary flood flows, as taken from high-water marks on McConnellsville dam, indicate 18.4 cubic feet per square mile per second.

(7) EAST BRANCH OF FISH CREEK.

The catchment area of this stream above Point Rock, where the gauging station is established, is quite different from that of the West Branch of Fish Creek above McConnellsville. The stream rises very rapidly and the surface soil is such as to give large run-offs. The maximum flood is reported as having occurred in the fall of 1897, with a total run-off of 8,400 cubic feet per second, or 80.5 cubic feet per square mile per second. The ordinary floods, as determined from high-water marks, are about 36.9 cubic feet per square mile per second.

(8) SALMON RIVER.

This stream nas a catchment area of 190.5 square miles above the point of gauging, of which about 10 to 20 square miles are flats, the balance of the catchment area having rather sharp slopes. The soil is sandy. The maximum flood is reported as occurring in the summer of 1888, and due to heavy summer rains. The maximum figures are 5,670 cubic feet per second, or 29.7 cubic feet per square mile per second. The ordinary floods do not exceed about 18.8 cubic feet per square mile per second.

The proposed Salmon River reservoir will have a water surface of about 7.5 square miles, and store about 7,500,000,000 cubic feet. The effect of this storage would be to very greatly reduce the floods on this stream below the reservoir.

(9) UPPER MOHAWK RIVER.

Nos. (9), (9a), (15), and (15a) of Table No. 124 give particulars of flood flows at Ridge Mills, 2 miles above Rome, and at Little Falls.

The dam at Ridge Mills, on which the observations have been made, is that of Rome waterworks, while at Little Falls the gauging station has been established at Gilbert's dam, the lowest on the stream. Mr. Harrison's observations of March, 1898, at Little Falls, were made on what is known as the middle dam.

Mr. Harrison's data, both at Ridge Mills and Little Falls, have been recomputed, using the Cornell University coefficients. The results are 5,266 cubic feet per second, or 34.5 cubic feet per square mile per second at Ridge Mills, and 23,749 cubic feet per second at Little Falls, or 18.2 cubic feet per square mile per second. These figures include the amount of water ordinarily passing through the water wheels. The catchment area above Ridge Mills is 152.5 square miles and above Little Falls 1,306 square miles, the ratio of Little Falls to Ridge Mills being 8.564. The observations at Ridge Mills and Little Falls cover the period from noon on March 12 to 6 a. m. on March 15, a second maximum at Little Falls occurring about 6 p. m. on March 13, the maximum at Little Falls occurring about 9 a. m. on March 14. If we assume the flow of the several tributary streams above Little Falls to have been the same as that of the main Mohawk River above Ridge Mills, the maximum discharge of the entire drainage area is found by multiplying 5,266, the flow in cubic feet per second at Ridge Mills, by 8.564, the ratio of the catchment areas. This gives a maximum inflow into the Mohawk River above Little Falls of about 45,000 cubic feet per second. Probably, however, this assumption is too large for the special case under consideration, as the flow of the Oriskany Creek at Oriskany, as determined by Mr. Harrison on March 12, 1898, was only 600 cubic feet per second, or 4.1 cubic feet per square mile per second.

If, however, we assume that at some time the total flow from the tributary streams above Little Falls will approximate about 35 cubic feet per square mile per second, it follows that we may expect an inflow into the valley above Little Falls of certainly 45,000 cubic feet per second, although probably in March, 1898, it did not reach that figure. As to why such a flow is possible, we may consider (1) that the tributary streams all have a rapid descent from the adjacent high ground, and (2) the large temporary storage of the flats above Little Falls.

By way of showing the character of the inflowing streams, the following data relating to the descent of a number of the more important ones are cited. In the following tabulation we have the name of the tributary, distance from head waters to the mouth, and the elevation of the head waters, the elevation being taken not at the extreme, but usually at some point where the stream branches, within a short distance of the extreme head waters.

Name of stream.	Distance from head waters to mouth.	Elevation of head waters above tide.
	Miles.	
Mohawk River, above Ridge Mills	23	1,066
Nine Mile Creek	10	760
Oriskany Creek	19	1,000 to 1,240
Saquoit Creek	15	1,200
Sterling Creek	6	1,000
Mayer Creek	7	1,280
West Canada Creek	64	2,300
East Canada Creek	19	1,600
Canajoharie Creek	15	1,350
Cayadutta Creek	12	800
Schoharie Creek	75	1,880
Cobleskill (tributary of Schoharie Creek)	20	1,177
Batavia Kill (tributary of Schoharie Creek)	17	2,000
Chuctenunda Creek	8	800
South Chuctenunda Creek	11	1,100
Alplaus Kill	12	600

As further showing that Upper Mohawk—the portion above Little Falls—must be, so far as delivery in the broad level valley is concerned, a relatively rapid stream, we may consider that this division of the catchment area is quite narrow, being at the extreme western end about 45 miles and at Utica about 25 miles. On the north side of the valley, Black River Canal, following the general course of the river and its chief tributary above Rome, the Lansing Kill, rises to an elevation of 1,200 feet on the Boonville summit in a distance of 25 miles. To the south of Utica the abandoned Chenango Canal, following a circuitous route, reaches an elevation of 1,126 feet on the Boucksville summit in a distance of about 24 miles.

The mean elevation of the Mohawk Valley proper, from a short distance above Little Falls to Rome, may be taken from about 380 to 420 or 430. At Rome, above feeder dam, the elevation of water surface above mean sea level is 430.5 feet; at the New York Central and Hudson River Railroad crossing, 4 miles east of Rome, it is 418.4 feet; at the New York Central and Hudson River Railroad crossing, 3 miles east of Utica, the water surface is 393.3 feet; at the mouth of the Schoharie Creek it is about 270 feet, and at the New York Central and Hudson River Railroad crossing at Schenectady it is 214 feet. The foregoing tabulation, which includes streams below Little Falls, as well as above, indicates that rapid-flood delivery is the marked characteristic of all the tributary Mohawk streams. The data given in Table 124 of flood flows may be further taken as substantiating this view.

The area of the flats between Little Falls and Rome as computed from the United States Geological Survey topographical sheets is about 21 square miles, this area including in effect the flats between 400 and 420 contours. Adding thereto somewhat for nearly level areas above the 420 contour, we may take total area on which temporary pondage may exist during flood flows at something like 30 square miles. The effect of this pondage, so long as the present natural conditions are maintained, will be to considerably lengthen the period of flood run-off at Little Falls, thus decreasing the maximum at that place.

The Mohawk River flood of August 24 to 26, 1898, may be referred to. On August 23 and 24 very heavy thunderstorms occurred throughout the central and eastern portions of the State. They were especially severe about Utica, with the result, so far as can be learned, of yielding a nearly unprecedented summer flood in Mohawk. The Mohawk flats between Herkimer and Rome were so far covered with water as to do great damage to standing crops. The water was still standing on the flats on the afternoon of August 27, but was down into the channel again on the afternoon of the 28th. On referring to Table No. 124, we learn that the Nine Mile Creek at Stittville, with a catchment area of 62.6 square miles, flowed on August 25 approximately 7,820 cubic feet per second, or 124.9 cubic feet per square mile per second. The West Canada Creek at Middleville, where the catchment area is 518.7 square miles, gave a flow on August 25, 1898, of about 12,950 cubic feet per second, or about 24.9 cubic feet per square mile per second. The East Canada Creek also showed a flow of 6,330 cubic feet per second, or 24.7 cubic feet per square mile per second. Probably these flows were for very short periods, perhaps two or three hours, because the highest flow over the middle dam at Little Falls, the one on which Mr. Harrison made his gaugings, was about 4 feet to 4.5 feet in depth, equivalent to from 12,000 to 14,000 cubic feet per second, the temporary storage of the flats reducing the quantity at Little Falls very greatly.

By way of showing the quantity of rainfall which caused the flood of August 24 and 25, 1898, the following precipitations at a number of points in the central and eastern portions of the State are cited from the monthly report of the New York State Weather Bureau:

Name of place.	Rainfall August 23.	Rainfall August 24.	Total.
	Inches.	*Inches.*	*Inches.*
Cooperstown	1.96	1.40	3.36
Oneonta	1.10	2.18	3.28
Gloversville	1.24	1.30	2.54
Little Falls (near city)	0.64	0.56	1.20
Little Falls reservoir (8 miles north)	1.68	2.78	4.46
Number Four	1.71	0.88	2.59
Kings Station	0.35	2.36	2.71
Albany	0.50	1.83	2.33
Greenwich	1.16	1.58	2.74
Rome	1.20	1.40	2.60
Saratoga Springs	0.23	1.79	2.02
Watertown	1.45	0.43	1.88

Taking all the facts into consideration, there seems to be no reasonable doubt but that the streams tributary to Mohawk River above Little Falls for a short time on August 24 or 25 delivered water into the flat area at the rate of perhaps 40,000 cubic feet per second. By way of illustrating further why this large inflow did not produce a greater flow at Little Falls, we may consider that for from thirty to fifty days previous to August 23 the rainfall on and in the vicinity of Mohawk catchment area had been rather low. The total for Mohawk Valley in July as deduced from Weather Bureau stations at Little Falls, Canajoharie, St. Johnsville, and Rome was 3.93 inches, 2.53 inches of this having fallen on July 18 and 19. The concentration of the rainfall of the month into these two days had the effect of sending a very large portion of it into the streams, only a small portion going to replenish ground water. On August 1 the Mohawk Valley record shows 1.18 inches precipitation, the total for that month being 7.12 inches. We may assume, therefore, that ground water was rather low August 23. Hence Mohawk flats were in shape to absorb a considerable portion of the water delivered upon them into the interstices below the surface. Assuming, as already stated, 30 square miles to be more or less affected by such an inflow, and further assuming the interstices of the soil of this 30 square miles to be for the first 8 or 10 feet of depth about 30 to 40 per cent of the whole volume, we reach the conclusion that the temporary storage of the flats may have been as much as 3,000,000,000 to 4,000,000,000 cubic feet, which sufficiently explains why the outgo at Little Falls did not exceed 12,000 to 14,000 cubic feet per second.

An application of the foregoing discussion of floods in Mohawk River above Little Falls may be made to the proposed deep-waterways channel in this way. So long as present conditions are maintained the flood flows above Little Falls are distributed and reduced about one-half in intensity at that place. If, however, the whole volume be taken into the new channel, conditions are so far changed as to make it necessary to dispose of the whole quantity at Little Falls practically at once. The author's view is, therefore, that the spillway arrangements of locks at that point should provide for at least 50,000 cubic feet per second if the whole flow of the tributary streams above that place be taken into the deep waterways canal. If, on the other hand, diversion channels are constructed diverting Mohawk River above Rome into Wood Creek catchment area, and Oriskany and Sauquoit creeks into an independent channel, delivering them at Little Falls, outside of the canal, then, in that case, of course proportionate reductions may be made.

The foregoing figures, however, do not take into account the extreme maximums; so far as can be now seen, from 40,000 to 50,000 cubic feet per second delivery into the flats above Little Falls is rather common. The extreme maximum must be considerably greater than this. Without being able to cite specific floods proving the statement, the author is, nevertheless, disposed to say, taking into account the known maximum floods of other streams of the State—as, for instance, Chemung, Genesee, and Croton rivers—that at some time Mohawk River above Little Falls may yield something like 60,000 to 70,000 cubic feet per second, or at the rate of perhaps 46 to 54 cubic feet per square mile per second.

A study of the flood flows of Mohawk River would be incomplete without some reference to the surface geology of the catchment area. The main trough of the valley lies entirely within the horizon of Hudson River and Utica shales, where the soils, aside from immediately in the flat, level valley, are heavy and compact. On the north side, beyond the horizon of the shales, Trenton limestone and calciferous and sand rock appear. At Little Falls, St. Johnsville, and Amsterdam these formations extend down into the valley to the thread of the stream. To the north of the Trenton limestone and calciferous sand rock the Laurentian granite appears, the headwaters of West and East Canada creeks lying in this formation, while the less extended streams on the north side terminate either in the shale or limestone and sand rock horizons. In the vicinity of Fonda, Johnstown, Gloversville, and Mayfield the shale formations extend for some distance to the north of the trough of the valley, as also they do farther east, to the north of Schenectady.

To the south of the trough of Mohawk Valley we have, first, the shales, followed in ascending series by the Medina and Oneida sandstones, the shales and limestones of the Clinton formation, the Niagara limestones, the rocks of the salt group, the Helderberg limestone, the Oriskany sandstone, the Onondaga limestone, and, finally, the extended area covered by the Catskill and Chemung sandstones. The headwaters of Schoharie Creek issue mostly from Catskill formation, although the extreme headwaters flow from off Oneonta sandstone, which, however, is closely allied to Catskill. The shorter streams on the south side issue from the horizon of Hudson and Utica shales, the same as short streams to the north.

The soils of a large proportion of Mohawk River catchment area are consequently heavy and impermeable, and further tend to give heavy run-offs at time of flood flow.

LOWER MOHAWK RIVER.

As regards flood flows, Mohawk River divides naturally at Little Falls. Below that point the flat area is relatively more restricted, and the flood flows probably larger in volume than at Little Falls. Serial number 20 of Table No. 124 gives particulars of the highest flood at Rexford Flats just below Schenectady, where the catchment area is 3,384.9 square miles. According to the Report on Water Power in the United States of the Tenth Census, in an extreme flood which occurred about 1860 to 1865, there is stated to have been a depth of 12 feet of water on the Cohoes dam, which is 1,400 feet in length. If such a depth actually occurred, the discharge may have been over 200,000 cubic feet per second. Probably, however, it was only temporary and due to an ice gorge at some point above. The information at hand does not indicate over about 78,350 cubic feet per second, or 23.1 cubic feet per square mile per second at Rexford Flats dam. The maximum must, however, be very much larger than this.

(10) NINE MILE CREEK.

The heavy run-off of this stream of August 25, 1898, of 7,820 cubic feet per second, or 124.9 cubic feet per square mile per second, has already been referred to and the reasons therefor given in discussing the Mohawk River. Mr. Harrison's gaugings of March 12, 1898, show 1,800 cubic feet per second, or 28.7 cubic feet per square mile per second.

(11) ORISKANY CREEK.

This stream is stated to have given a flood flow in the spring of 1896 of 7,510 cubic feet per second, or 52.7 cubic feet per square mile per second. On March 12, 1898, Mr. Harrison's gaugings showed 900 cubic feet per second flowing.

(12) ORISKANY CREEK AT COLMANS.

A gauging station was also established at Colmans on the Oriskany Creek, where the catchment area is 140.7 square miles, the area at Oriskany being 144.3 square miles. The object of establishing the Colmans station was to obtain comparative data as to flow over two dams on the same stream. The maximum flood reported is for the spring of 1888, when the extreme flow was 7,830 cubic feet per second, or 55.8 cubic feet per square mile per second. These figures, it will be noticed, compare very closely with the flow reported as taking place at Oriskany in the spring of 1896.

(13) SAUQUOIT CREEK.

The figures for this stream are not very definite, but, as far as they go, indicate that flows of 53.4 cubic feet per square mile per second are common.

(14) WEST CANADA CREEK.

The extreme flow of this stream is reported to have occurred August 25, 1898, as already discussed in the chapter on Mohawk River. On March 20, 1898, after the extreme flow of last spring had passed by, Mr. Harrison determined a flow of 4,360 cubic feet per second, or 8.4 cubic feet per square mile per second.

(15) MOHAWK RIVER AT LITTLE FALLS.

The information at this station has already been presented in the chapter on Mohawk River.

(16) EAST CANADA CREEK.

The maximum flow of this stream is also reported as having occurred August 25, 1898, amounting to 6,330 cubic feet per second, or 24.7 cubic feet per square mile per second. It is probable that the heavy rainfall of August 23 and 24 did not extend over the greater part of this basin. At North Lake the rainfall of these two days was only 0.89 inch.

(17) GAROGA CREEK.

So far as can be learned, the flow of this stream is tolerably constant, extreme floods not having occurred in recent years. The reported figures indicate 15.8 cubic feet per square mile per second.

(18) CAYADUTTA CREEK.

This stream has a catchment area of 40 square miles and is reported to have given in 1896 a flow of 72.4 cubic feet per square mile per second.

(19) SCHOHARIE CREEK.

The catchment area of this stream above the point of gauging is 946.7 square miles and is reported to have given a maximum flood in 1892 of 41,300 cubic feet per second, or 44 cubic feet per square mile per second. The ordinary floods of this stream are from 30,000 to 35,000 cubic feet per second. As stated in the chapter on the Mokawk River, the headwaters of Schoharie Creek issue from the horizon of the Catskill sandstone, which is closely allied to Chemung, from whence it is probable that, like Genesee River, in the western part of the State, the floods are not only frequent but heavy. Indeed, tradition ascribes to this stream exceedingly heavy floods.

(20) MOHAWK RIVER AT REXFORD FLATS.

Already discussed in the chapter on Mohawk River.

(21) HUDSON RIVER.

The maximum flood of this stream is stated to have occurred in the spring of 1869, and amounted to about 70,000 cubic feet per second, or 15.5 cubic feet per square mile per second. Gaugings have been made at Mechanicville for eleven years, the highest flood during the gauging period having been 59,400 cubic feet per second on April 9, 1896. The large pondage on natural lakes and ponds on the headwaters of Hudson tends to reduce the severity of the floods. Table No. 124 also includes information as to floods at Fort Edward, on Hudson River, as derived from the gaugings kept at that place for the last three years. On April 18, 1896, the water stood on the crest of the Fort Edward dam at the height of 8.16 feet, giving a computed flow of 41,675 cubic feet per second, or 14.7 cubic feet per square mile per second. The water wheels of the Fort Edward mill of the Glens Falls Paper Mill Company, when all running, use 4,000 cubic feet of water per second. The gauging record shows that they were all idle on April 18, 1896. The ordinary floods at Fort Edward, as determined from the last three years' record, may be taken at about 26,000 cubic feet per second, or 9.2 cubic feet per square mile per second.

(22) TO (28) WEST BRANCH OF FISH CREEK.

In this division will be found such information as has been obtained as to flood flows of the upper section of West Branch of Fish Creek, the computed quantities being based on actual measurements of the lengths and on approximate cross sections of the several dams, as well as on well-defined flood marks at each dam.

(29) FISH CREEK.

According to Mr. Harrison, the flow of Fish Creek below the mouth of Wood Creek on March 15, 1898, was 7,597 cubic feet per second.

(30) FISH CREEK.

The previous gauging, No. (29), of Fish Creek included the flow of both Fish and Wood creeks, while the present one, No. (30), includes only the East and West branches of Fish Creek as gauged March 14, 1898, by Mr. Harrison at a point a short distance below Taberg station. The flow was found to be 5,875 cubic feet per second, or 15.2 cubic feet per square mile per second.

(31 AND 32) MAD RIVER.

This stream is tributary to the West Branch of Fish Creek at Camden. The reported figures indicate a maximum flow of 21 cubic feet per square mile per second.

(33) NORTH BRANCH OF BIG SANDY CREEK.

This stream, with several following, is tributary to the proposed Black River feeder. It descends rapidly from a region of heavy soils underlaid by Trenton limestone, the maximum flow reported amounting to 67.3 cubic feet per square mile per second.

(34) SOUTH BRANCH OF BIG SANDY CREEK.

This stream is also tributary to Black River feeder. The maximum flood reported 87.7 cubic feet per square mile per second.

(35) SKINNER CREEK.

This stream has a very small catchment area of 6.4 square miles. The maximum flood is given at 124.2 cubic feet per square mile per second.

(36) TROUT BROOK.

The maximum flood reported on this stream is 50.6 cubic feet per square mile per second.

(37) SALMON RIVER AT ALTMAR.

A comparison of the data at this place with those obtained at the gauging station 1 mile above Salmon Falls shows as follows:

	Cubic feet per second.		Cubic feet per second per square mile.	
	Maximum.	Ordinary.	Maximum.	Ordinary.
Gauging station	5,670	3,580	29.7	18.8
Altmar	6,100	4,045	27.6	18.3

These results compare as well as flood computations from data of different dams can be expected to compare.

(38) BEAVER DAM CREEK.

This stream is reported as giving a maximum of 111 cubic feet per square mile per second from a catchment area of 20.7 square miles.

(39 TO 52) FLOODS ON BLACK RIVER AND TRIBUTARIES.

Heavy floods have occurred on Black River in 1807, 1833, 1850, 1857, 1862, 1866, 1869, and 1896. The flood of April 20 to 24, 1869, was specially heavy, there being a heavy snow fall over nearly the entire catchment area, which melted rapidly that year. In addition to the ground being heavily covered with snow, about 2.2 inches of rain fell in some parts of Black River catchment basin from April 17 to 23, though this quantity of rain, which was only over a portion of the catchment area, hardly explains the severity of the flood. The greater portion of the water evidently came from rapid melting of snow.

On April 21, 1869, the banks of North Lake reservoir, a structure maintained by the State for the purpose of storing water for Black River and Erie canals, gave way, precipitating into the already heavily swollen stream about 350,000,000 cubic feet of water. This accident was made the basis of large claims for damages against the State, which were tried before the canal appraisers in the summer and fall of 1869. The testimony in this case, which included two large octavo volumes of over 1,200 pages, is the source of the following information as to flood flows of Black River and its tributaries in the spring of 1869:

The Black River flood of April, 1869, was studied by David M. Green, Samuel McElroy, William J. McAlpine, L. L. Nichols, and other hydraulic engineers of that day. The testimony may, therefore, be referred to as furnishing unusually good flood data. The information embodied in Table No. 124, serial numbers 39 to 50, inclusive, is derived from a table prepared by L. L. Nichols, to be found in volume 1 of the testimony, page 640. Mr. Nichols states in his testimony that he not only measured the lengths of the crests of the dams on the several streams for which the flood flows are given, but that he also instrumentally determined the height of flood marks above the crests. This work was done within a few months after the flood, while the matter was fresh in the minds of everybody. He further states that the tabulated flood flows were obtained by computing with Francis's formula for discharge over sharp-crested weirs with clear overfall. The dams, however, on which the flood flows were measured were of such a form as to indicate the use of Cornell experiments Nos. 1 or 2, as giving more nearly the actual flows, and accordingly the flows have been recomputed for Table No. 124 by the use of the said coefficients. By way of showing the relation between the flows as per Francis's formula and by Cornell experiments Nos. 1 and 2, the following table is submitted, the last column giving the difference between Francis's formula and the mean of experiments Nos. 1 and 2 as a per cent of the flow by Francis's formula:

Head on crest, in feet.	Cubic feet per second per foot.		Difference of columns 2 and 3.	Difference as a per cent of flow by Francis's formula.
	Cornell experiments Nos. 1 and 2.	Francis's formula.		
(1)	(2)	(3)	(4)	(5)
0.5	[a]1.17	1.18	0.01	0.8
1.0	[a]3.44	3.33	[a]0.11	3.3
1.5	[a]6.59	6.12	0.47	7.7
2.0	10.50	9.42	1.08	10.4
2.5	14.59	13.16	1.43	10.8
3.0	19.12	17.30	1.82	10.5
3.5	24.20	21.90	2.30	10.5
4.0	29.66	26.64	3.02	11.3
4.5	35.40	31.78	3.62	11.4
5.0	41.46	37.20	4.26	11.5

[a] Mean taken.

In passing it may be remarked that with the exception of Hudson, Chemung, Croton, and Genesee rivers all of the flood flows over dams included in Table No. 124 have been computed by either Bazin's coefficients or by the coefficients deduced from the Cornell University experiments.

According to statement of Samuel McElroy, in Black River flood cases, in its course from head waters in Hamilton County to Lake Ontario at Dexter, Black River has topographically three distinct subdivisions: (1) The upper valley above Lyons Falls; (2) the long level stretch from Lyons Falls to Carthage, and (3) the lower valley with rapid fall from Carthage to Black River Bay. The second division, from Lyons Falls to Carthage, is a broad, flat valley with a bottom area of from 30 to 35 square miles.

The catchment area of the whole river above Dexter is 1,930.2 square miles; above Carthage, 1,812.2 square miles, and above the mouth of the Moose River, 463 square miles. The following are the areas of

the principal tributaries: Deer River, at mouth, 102 square miles; Beaver River, at mouth, 337.5 square miles; Moose River, at mouth, 415.5 square miles; Woodhull Creek, at mouth, 108.4 square miles; Otter Creek, above Casler's dam, 63 square miles; Independence Creek, 93.2 square miles.

The descent of the river above Lyons Falls, as well as below Carthage, is very rapid. At North Lake reservoir the elevation is 1,821 feet above tide; at Forestport, 1,126 feet; at Lyons Falls, above the dam, 799 feet, and at Carthage, 723 feet. At Dexter, at Lake Ontario level, the elevation is 247 feet.

Throughout the flat portion of the stream, between Lyons Falls and Carthage, the river at ordinary stages ranges from 250 to 300 feet wide, increasing to about 500 feet above the Carthage dam, which is 966 feet long. In a powerful freshet like that of 1869 the flats on each side are overflowed to a great width and considerable depth, the quantity of water accummulated in large floods being computed at from 4,000,000,000 to 6,000,000,000 cubic feet. If we take into account the water held in the interstices of the soil, the temporary storage is considerably higher than indicated by these figures. In this reach of the river, which is alluvial in its formation, there are now two dams of 4 feet each, with locks for facilitating navigation.

The river has no affluents of any magnitude below Carthage, but a few miles above that place, on the west side, Deer River comes in. There are also a number of secondary creeks between Deer River and Lyons Falls. On the east side the chief affluents are Beaver River, Independence Creek, Otter Creek, and other secondary creeks below Lyons Falls, with Moose River flowing in just above Lyons Falls. All of these streams between Carthage and Lyons Falls have very rapid descents, with consequent large flood flows.

The following table gives the catchment area of Otter and Independence creeks, as well as of Beaver and Deer rivers and Black River, including Moose above Lyons Falls, together with the flood flows for April, 1869, the flood flows having been corrected from Mr. Nichols's original table by the use of the Cornell coefficients in the manner already described:

Name of stream.	Catchment area.	Flood flow.
	Sq. miles.	*Cu. ft. per second.*
Otter	63.0	1,944
Independence	93.2	6,200
Beaver	322.3	5,382
Deer	100.8	7,881
Black	878.5	40,400
Total	1,457.8	61,807

From this table it appears that a catchment area of 1,457.8 square miles yielded a maximum flood flow about April 22, 1869, of 61,807 cubic feet per second, or at the rate of 42.3 cubic feet per square mile per second. The total area above Carthage, however, is 1,812.2 square miles. Assuming the same average flow from the balance of the catchment area as from the 1,457.8 square miles included in the streams tabulated, it follows that the total inflow to the pond area between Carthage and Lyons Falls was at the rate of 75,830 cubic feet per second. Table No. 124 shows, however, that the greatest flow at Carthage, which occurred April 23, 1869, was only 39,529 cubic feet per second, the effect of the temporary pondage above that place having been to reduce the flood from about 76,000 cubic feet per second to about 40,000 cubic feet per second.

Inasmuch as there are no affluents to the stream below Carthage, there is no special reason why the flood flow below that place should have any higher rate than at Carthage. The reported flow at Watertown in April, 1869, of 39,696 cubic feet per second is therefore considered as fairly justifying the Carthage figure. A comparison of the two shows at any rate that the error is not likely to be more than a few per cent. As shown by table No. 124, flood flows of from 27,000 to 28,000 cubic feet were measured on Black River in 1896 and in 1898.

(53) CROTON RIVER.

The watershed of Croton River consists of a broken, hilly country with its surface soil composed principally of sand and gravel. Clay, hardpan, and peat, while found in a few localities, are for the whole area only present to a limited extent. The rock formation consists generally of gneiss, although strata of limestone, some micaceous and talcose slates, with veins of granite, serpentine, and iron ore, occur in a few places. The catchment area is about 338 square miles above the old Croton dam, at which point daily run-off measurments have been made since 1867. According to J. J. R. Croes there is a well-attested case of a maximum flood of 25,376 cubic feet per second, or 74.9 cubic feet per square mile per secomd. In reference to these figures it may be remarked that probably they have been obtained by the use of Francis's formula. The profile of the old Croton dam, however, shows a rounded crest which, according to Bazin's coefficient, Series No. 193, would give, above 5 feet depth on the crest, a discharge from 37 to 38 per cent higher than Francis's formula. The maximum flood of the Croton may therefore be from 30,000 to 35,000 cubic feet per second, or possibly as high as 103 cubic feet per square mile per second.

(54) TO (56) GENESEE RIVER.

Floods have occurred on this stream in 1815, 1835, 1857, 1865, 1878, 1894, and 1896, the heaviest of all being the flood of March 19, 1865, at which time, according to the best available information, the flow at Rochester must have been in the vicinity of 40,000 cubic feet per second, or at the rate of 16.5 cubic feet per square mile per second

The general description of the subdivisions of the topography of Black River may be taken as applying to Genesee River. Within the limits of the city of Rochester the stream falls about 260 feet, while immediately to the south of Rochester begins an extended area of from 60 to 80 square miles of flat valley, which continues to Mount Morris and Dansville, a distance of over 50 miles. Above Mount Morris the stream rises rapidly to Portage, where another area of broad valley begins, though much less extensive than that between Rochester and Mount Morris. The following gives the elevation of Genesee River at various points throughout its course:

	Feet.
Mean surface of Lake Ontario	247
Crest of the feeder dam in south part of the city of Rochester	510
Low-water surface of river at New York, Lake Erie and Western Railway bridge near Avon	538
Crest of old Mount Morris power dam	605
Water surface just above Upper Falls at Portage	1,080
Water surface at New York, Lake Erie and Western Railway bridge near Belvidere	1,333
Extreme head waters in Potter County, Pa	2,000

As in the case of Mohawk and Black rivers, the temporary pondage between Rochester and Mount Morris and Dansville tends to reduce the maximum flood at Rochester far below what it would be without such temporary storage. Thus, on May 21, 1894, the upper river gave at Mount Morris, where the catchment area is 1,070 square miles, a maximum flood of 42,000 cubic feet per second, or 39.2 cubic feet per square mile per second. At Rochester, however, the flow of the May, 1894, flood did not at any time exceed about 20,000 cubic feet per second. The author has discussed Genesee River flood of May, 1894, extensively in a report on the Genesee storage project in the annual report of the State engineer and surveyor for 1896, to which reference may be made for full detail.

On June 1, 1889, Genesee River at Rochester gave a flood flow of about 27,000 cubic feet per second. There is no information at hand as to the flow of the upper river on that date, but inasmuch as the rainfall of the upper catchment area is known to have been exceedingly heavy there is no doubt but that the stream above Mount Morris gave a heavy flood flow.

(57) CHEMUNG RIVER.

According to Francis Collingwood, this stream gave, June 1, 1889, a flow of 138,000 cubic feet per second, or 67.1 cubic feet per square mile per second. Full particulars may be obtained in Mr. Collingwood's Report on Floods at Elmira.

Since writing the paragraph about flood flows on Seneca River (No. 1) the author has received additional information in regard to Seneca River flood of March, 1865. As already stated, the flood of March, 1865, was exceedingly serious throughout the whole of western and central New York. It probably represents the most widely distributed flood of the last forty or fifty years in this region. Positive statements are made to the effect that about the middle of March, 1865, the water on the Baldwinsville dam stood for two or three days at or about the depth of 4.75 feet, giving a flow over the dam, according to the method of computation adopted, of 12,000 cubic feet per second. As to whether the wheel service in 1865 was the same as at present we have no means of positively determining, but evidently it was not very different, as the large flouring mills at Baldwinsville and other manufacturing establishments now there were mostly in operation previous to 1865. Assuming, therefore, that the wheel service was the same and that the wheels were running, the maximum flood may possibly have been about 19,950 cubic feet per second, or 6.4 cubic feet per square mile per second. In any case it is very certain that only rarely is anything like this figure reached.[1]

On reviewing the data herein embodied it appears evident that the question is likely to be raised as to whether the several dams over which the flood flows are given are submerged at the time of extreme flow, thus changing the conditions from that of flow with free overfall to that of a submerged weir. As regards the gauging stations, serial Nos. 1 to 20, it may be pointed out that the following three dams are likely to be submerged with extreme flood flows, viz: Schoharie Creek at Fort Hunter, height of dam 6 feet; West Canada Creek at Middleville, height 5 feet; and Oriskany Creek at Oriskany, height 4 feet. As to the effect of submergence in increasing or decreasing the discharge, Table No. 125 is submitted, in which is shown the percentage of the flow over a sharp-crested weir with free overfall that will flow over a weir 5.5 feet in height under different depths of submergence. This table has been computed from Bazin's experiments for various heads within the limits to which his coefficients may be applied, as stated in the Annales des Ponts et Chaussées, 1894, pages 298 to 310.

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[1] We may observe further that since the old dam was standing in 1865, probably the flow was greater for a given depth than at present. The flood flow may therefore have reached 22,000 to 26,000 cubic feet per second. Even at 26,000 cubic feet per second the flow is only about 8.5 cubic feet per square mile per second.

TABLE No. 125.

Head on upstream side of crest, in feet = H.	Flow over a sharp-crested weir. 1 foot in length (cubic foot per second).	Difference in elevation of the water surfaces on the upstream and downstream sides of the crest = H — H′.									
		5 feet.		4 feet.		3 feet.		2 feet.		1 foot.	
		Depth of submergence = H′.	Per cent of flow over a standard sharp-crested weir.	Depth of submergence = H′.	Per cent of flow over a standard sharp-crested weir.	Depth of submergence = H′.	Per cent of flow over a standard sharp-crested weir.	Depth of submergence = H′.	Per cent of flow over a standard sharp-crested weir.	Depth of submergence = H′.	Per cent of flow over a standard sharp-crested weir.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1.5	6.1	......	......	......	......	......	......	......	......	0.5	93.4
2.0	9.4	......	......	......	......	......	......	......	......	1.0	87.0
2.5	13.2	......	......	......	......	......	......	0.5	99.0	1.5	82.6
3.0	17.3	......	......	......	......	......	......	1.0	96.0	2.0	80.0
3.5	21.9	......	......	......	......	0.5	102	1.5	93.6	2.5	77.0
4.0	26.6	......	......	......	......	1.0	100	2.0	91.0	3.0	74.0
4.5	31.8	......	......	0.5	103	1.5	98	2.5	88.0	3.5	72.4
5.0	37.2	......	......	1.0	101	2.0	96	3.0	86.4	4.0	70.0
5.5	43.0	0.5	104	1.5	100	2.5	95	3.5	85.0	4.5	69.0
6.0	49.0	1.0	103	2.0	99	3.0	93	4.0	84.0	5.0	68.0
6.5	55.2	1.5	102	2.5	98	3.5	92	4.5	83.0	5.5	67.0
7.0	61.7	2.0	101	3.0	97	4.0	91	5.0	82.0	6.0	66.4
7.5	68.4	2.5	101	3.5	96	4.5	90	5.5	80.0	6.5	64.6
8.0	75.4	3.0	......	4.0	95	5.0	89	6.0	80.0	7.0	......
8.5	82.5	3.5	......	4.5	94	5.5	......	6.5	......	7.5	......
9.0	89.9	4.0	......	5.0	......	6.0	......	7.0	......	8.0	......

In Table No. 125, column (1) gives the head on upstream side of crest in feet, and column (2) the flow over a sharp-crested weir 1 foot in length, in cubic feet per second. Bazin's experiments on flow over sharp-crested weir show substantial accord with those by Mr. Francis. Reference to a translation of Bazin's experiments on flows over sharp-crested weirs may be made to Proceedings of the Engineers' Club of Philadelphia for January, 1890, July, 1892, October, 1892, and April, 1893. Column (3) of the foregoing table shows depths of submergence when the difference in elevation of the water surfaces on the upstream and downstream sides of the crest are 5 feet, column (4) being the per cent of flow under the conditions of column (3) over a standard sharp-crested weir. Columns (5) to (12), inclusive, show the same data for difference in elevation of the two water surfaces of 4 feet, 3 feet, 2 feet, and 1 foot.

Table No. 125, it will be noticed, compares the flow on a submerged weir with free overfall on a sharp-crested weir. In order to certainly decide that with sloping dams and dams with adhering nappes on the front face, etc., the flow will not be greatly decreased, reference may be made to the table on page 806, where the mean of Cornell University experiments Nos. 1 and 2 are compared with flows as per Francis's formula. It appears safe to assume from such comparison that within the limits of submergence actually occurring on the dams here considered, the submerged flows are as great as on those with free overfall. Hence we have no reason for supposing, after the water reaches the critical height where submergence begins, that within the limits of a foot or two there is any material decrease in discharge, and consequently any large reduction to be made in the figures of Table No. 124.

Further as to effect of submergence of drowned weirs, see statements translated from Bazin on pages 667 and 668.

By way of further illustrating the relation of submerged flow to free overfall flow, we also include Table No. 126, computed by Mr. Herschel's formula for 1 foot of length of crest, the formula being

$$Q = 3.33\ L\ (N\ H)^{\frac{3}{2}}$$

Mr. Herschel's formula was derived by a discussion of the experiments of Mr. Francis, also those of Messrs. Fteley and Stearns. In this formula N is a constant, the value of which depends on the ratio $\frac{H'}{H}$ of the heads on the upstream and downstream sides of the crest. H′ equals the depth of submergence in feet.

TABLE NO. 126.

Head on upstream side of crest in feet - H.	Discharge in cubic feet per second (Francis's formula).	Difference in elevation of the water surfaces on the upstream and downstream sides of the crest = H — H′.								
		6 feet.			5 feet.			4 feet.		
		H′.	Discharge in cubic feet per second.	Discharge as a per cent of flow by Francis's formula.	H′.	Discharge in cubic feet per second.	Discharge as a per cent of flow by Francis's formula.	H′.	Discharge in cubic feet per second.	Discharge as a per cent of flow by Francis's formula.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
4.0	26.6	....	....	....	....	....	....	0.0	26.6	100.0
4.5	31.8	....	....	....	....	....	....	0.5	32.0	100.6
5.0	37.2	....	....	....	0.0	37.2	100.0	1.0	36.4	97.8
5.5	43.0	....	....	....	0.5	43.3	100.7	1.5	40.8	94.9
6.0	49.0	0.0	49.0	100.0	1.0	48.4	198.8	2.0	45.3	92.3
6.5	55.2	0.5	55.7	100.9	1.5	53.3	86.5	2.5	49.8	90.2
7.0	61.7	1.0	61.4	99.5	2.0	58.2	94.3	3.0	54.3	88.0
7.5	68.4	1.5	66.9	97.8	2.5	63.2	92.4	3.5	58.9	86.1
8.0	75.4	2.0	72.3	95.9	3.0	68.3	90.6	4.0	63.6	84.3
8.5	82 5	2.5	77.6	94.0	3.5	73.4	88.9	4.5	68.1	82.5
9.0	89.9	3.0	83.1	92.4	4.0	78.5	87.3	5.0	72.8	80.9
9.5	97.5	3.5	88.7	91.0	4.5	83.6	85.7	5.5	77.3	79 3
10.0	105.3	4.0	94.8	90.0	5.0	88.7	84.2	6.0	81.9	77.8

LAND AND WATER SURFACE EVAPORATION IN OSWEGO RIVER BASIN.

As an interesting conclusion it may be pointed out that owing to the large area of water surface, marsh, and flat valleys in Oswego River basin the evaporation loss from this catchment area must be relatively large. It will therefore result in an extremely dry year that, even though this stream has large pondage area, its minimum flow will not be larger than that of other New York State streams with much less poudage. Estimates of water yield from this stream in the minimum year must therefore be very conservative. By way of illustrating the large evaporation loss from Oswego Basin we may consider the following tabulation:

Kind of area.	Square miles.	Per cent of total area.	Mean annual evaporation.	Proportionate evaporation on whole area.
	(1)	(2)	(3)	(4)
			Inches.	*Inches.*
Water surface	309.3	6.18	34.0	2.10
Marsh	220.7	4.41	60.0	2.65
Upland	4,472.0	89.41	26.2	23.42
Total	5,002.0	100.00		28.17

In this tabulation column (3) gives the mean annual evaporation for different kinds of evaporating surface. The annual evaporation from water surface is taken at 34 inches, as derived from the Rochester evaporation data, while the annual evaporation from a marsh area is taken at 60 inches. This latter figure is arrived at by considering that inasmuch as marsh areas are saturated with water they present evaporation conditions quite similar to water surfaces in the particular that the supply of water is constant and evaporation goes on continuously; they are also covered with a vigorous growth of water-transpiring vegetation. Marsh grass, flags, and other semiaquatic plants, which grow vigorously in such places, are all large consumers of water.

In the discussion of a paper on the introduction of irrigation in new countries, as illustrated in northern Colorada,[1] Baldwin Latham, M. Inst. C. E., stated that, beginning in June, 1870, he discharged sewage upon a definite area planted with rye grass at the Beddington-Croyden sewage farm, the grass being so placed in a water-tight tank, provided with suitable underdrains and means of collecting water flowing off, that definite results could be obtained. From June 18, 1870, to June 12, 1871, a period of 360 days, during which time 20.03 inches of rain fell, the water evaporated from a square yard of surface amounted to 8,712 pounds, or to a depth of 186.3 inches, in a year. Experiments on another plat during the year 1871–72 gave for a period of 370 days, with a rainfall of 24.98 inches, a total application of water of 4,263 pounds per square yard, amounting to a depth of 91.2 inches over the area. It is in view of these results that it appears reasonable to assume the evaporation from a marsh area in central New York at not less than 60 inches per year.

The figure of 26.2 inches per year for evaporation from upland areas has been derived from Genesee River data, Oswego River basin being same as Genesee, substantially deforested. The mean annual rainfall of Upper Genesee River catchment area, as determined for a period of nine years, is 40.33 inches, and the mean evaporation 26.18 inches. The mean rainfalls of Oswego River basin are as follows:

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[1] See Proc. Inst. C. E., Vol. LXXIII (1883), p. 185.

Name of place.	Number of years' observations.	Rainfall of each station.	Name of place.	Number of years' observations.	Rainfall of each station.
		Inches.			*Inches.*
Auburn	28	35.44	Onondaga	16	31.55
Baldwinsville	8	39.54	Oswego	46	36.65
Canandaigua	10	36.07	Palermo	45	36.96
Cazenovia	19	38.76	Perry City	10	40.09
Demster	6	39.13	Phœnix	6	38.38
Fleming	9	32.35	Pompey	21	32.37
Geneva	25	30.86	Rome	8	47.50
Ithaca	25	33.97	Romulus	7	35.24
Ledyard	7	33.21	Skaneateles	4	38.32
Lyons	10	34.40	Wedgwood	10	38.70
North Volney	13	36.15			
Oneida	10	64.83	Mean annual rainfall		36.70

The approximately true mean annual rainfall of the entire basin of 36.70 inches has been obtained by giving the individual records weight in proportion to their length; that is to say, the mean annual rainfall at each station has been multiplied by the length of the record in years, and the sum of the products so obtained divided by the total number of years' observations. This figure must, however, be considered an approximation merely, because what is really wanted are the subdivisions of the entire drainage area, with their proportionate rainfalls.

With a mean annual rainfall of 36.70 inches and a mean annual evaporation of 28.17 inches, we find the mean annual run-off to be 7.53 inches. However, with lower rainfall than on Genesee River, the evaporation will be lower and we may expect a mean annual run-off of perhaps 10 inches. It is the author's present opinion that in an extremely dry year the run-off of Oswego River will not exceed about 6 inches, the maximum run-off being probably about 15 to 18 inches.

PROBABILITIES OF FLOODS IN ANY GIVEN MONTH IN CENTRAL NEW YORK.

The usual flood months in western New York are March, April, May, and occasionally September and October. Occasional heavy floods occur as late as June 1 to 10, due to heavy rainfall in the latter part of May. The following statements and tables relating to rainfall in western New York show the tendency to floods late in the spring:

At Rochester total monthly rainfalls of about 6 inches have occurred in May nine times in the period from 1834 to 1898, inclusive.

At Oswego total monthly rainfalls of from 5.95 inches to 7.03 inches have occurred in May three times in the period from 1844 to 1898, inclusive.

At Palermo total monthly rainfalls of about 6 inches have occurred in May four times in the period from 1854 to 1898, inclusive.

At Ithaca total monthly rainfalls of about 6 inches have occurred in May six times in the period from 1828 to 1898, inclusive.

At Lowville total monthly rainfalls of about 6 inches have occurred in May twice in the period from 1827 to 1898, inclusive.

At Utica total monthly rainfalls of about 6 inches have occurred in May four times in the period from 1826 to 1893, inclusive. In 1889 it was 8.69 inches for the month of May; in 1892, 7 inches, and in 1893, 7.84 inches.

At Geneva total monthly rainfalls of over six inches have occurred in May twice in the period from 1851 to 1893, inclusive.

At Cooperstown total monthly rainfalls of over 6 inches have occurred in May four times in the period from 1854 to 1898, inclusive.

At Albany total monthly rainfalls of over 7 inches have occurred in May seven times in the period from 1826 to 1898, inclusive.

By way of further illustrating the possibility of serious floods in the State of New York, the following tabulation of the heaviest precipitations at several points in the State for the different months has been prepared:

Year in which heaviest monthly rainfall occurred.	Name of place.	Amount of heaviest rainfall.	Year in which heaviest monthly rainfall occurred.	Name of place.	Amount of heaviest rainfall.
January.		*Inches.*	*May.*		*Inches.*
1878	Rochester	8.05	1894	Rochester	6.87
1884	Oswego	6.49	1883	Oswego	7.03
1897	Palermo	6.78	1867	Palermo	6.90
1892	Ithaca	3.78	1894	Ithaca	7.34
1855	Lowville	4.81	1893	Lowville	6.78
1836	Utica	8.06	1890	Utica	8.09
1863	Geneva	6.78	1867	Geneva	6.59
1861	Cooperstown	4.31	1890	Cooperstown	8.84
1891	Albany	6.12	1890	Albany	5.19
February.			*June.*		
1896	Rochester	5.37	1892	Rochester	6.68
1896	Oswego	4.90	1889	Oswego	9.81
1886	Palermo	7.20	1865	Palermo	8.80
1887	Ithaca	4.21	1883	Ithaca	7.54
1831	Lowville	5.71	1835	Lowville	6.75
1840	Utica	6.20	1889	Utica	9.19
1856	Geneva	3.26	1857	Geneva	8.14
1887	Cooperstown	5.21	1855	Cooperstown	9.76
1883	Albany	4.63	1889	Albany	6.43
March.			*July.*		
1873	Rochester	7.02	1897	Rochester	6.37
1881	Oswego	5.08	1874	Oswego	7.62
1873	Palermo	6.10	1874	Palermo	6.00
1896	Ithaca	4.75	1889	Ithaca	6.73
1871	Lowville	5.11	1848	Lowville	8.29
1888	Utica	7.50	1827	Utica	7.60
1862	Geneva	5.23	1889	Geneva	5.31
1887	Cooperstown	4.32	1863	Cooperstown	7.92
1876	Albany	4.28	1874	Albany	6.18
April.			*August.*		
1874	Rochester	4.99	1886	Rochester	7.26
1886	Oswego	3.66	1893	Oswego	6.47
1863	Palermo	6.20	1892	Palermo	7.45
1894	Ithaca	4.84	1885	Ithaca	8.14
1857	Lowville	5.74	1892	Lowville	8.76
1842	Utica	6.69	1832	Utica	11.44
1854	Geneva	5.20	1864	Geneva	7.14
1854	Cooperstown	7.12	1885	Cooperstown	9.08
1874	Albany	4.97	1885	Albany	7.58

Year in which heaviest monthly rainfall occurred.	Name of place.	Amount of heaviest rainfall.	Year in which heaviest monthly rainfall occurred.	Name of place.	Amount of heaviest rainfall.
September.		*Inches.*	*November.*		*Inches.*
1876	Rochester	5.69	1877	Rochester	5.45
1890	Oswego	6.33	1897	Oswego	6.56
1890	Palermo	7.55	1897	Palermo	8.17
1890	Ithaca	6.62	1886	Ithaca	6.03
1847	Lowville	5.36	1897	Lowville	5.81
1890	Utica	8.27	1886	Utica	7.10
1890	Geneva	6.11	1857	Geneva	4.68
1890	Cooperstown	7.24	1858	Cooperstown	5.38
1890	Albany	8.91	1886	Albany	5.49
October.			*December.*		
1873	Rochester	8.67	1888	Rochester	6.17
1878	Oswego	7.55	1878	Oswego	10.49
1862	Palermo	7.90	1878	Palermo	7.95
1898	Ithaca	5.87	1881	Ithaca	4.75
1850	Lowville	5.80	1893	Lowville	5.81
1885	Utica	7.95	1881	Utica	8.64
1857	Geneva	6.30	1850	Geneva	6.46
1857	Cooperstown	6.65	1881	Cooperstown	6.02
1877	Albany	7.86	1878	Albany	6.16

CONTROL OF FLOODS IN MOHAWK VALLEY.

In the chapter on Flood Flows of Streams in the State of New York, Table No. 124 gives the maximum and ordinary flood flows of various streams of New York State, including Mohawk River. The range of Mohawk floods is there so clearly shown as to render further discussion unnecessary here.

The control of floods in Mohawk Valley may be considered from two points of view, either to construct flood reservoirs on the tributary streams, or to make the canalized river of such dimensions as to certainly carry the extreme floods, whatever they may be, providing at each dam or lock sufficient length of spillway to pass the extreme flood flows without too great fluctuation.

In regard to control by flood reservoirs, a study of existing maps and reconnoissance showed that this method was, on the whole, impracticable. Several of the streams tributary to Mohawk River have large catchment areas, as, for instance, Schoharie Creek, 947 square miles; East Canada Creek, 286.6 square miles, and West Canada Creek, 568.7 square miles. With the exception of Schoharie Creek there are no locations on any of these streams for large reservoirs, and even on Schoharie Creek the location is such as to make the project very expensive. The available location on Schoharie Creek is just above the village of Esperance, not far from the boundary line between Schenectady and Schoharie counties, where the valley narrows, and it is probable that an effective barrage from 150 to 160 feet in height could be made, creating a reservoir from 16 to 17 miles in length and averaging 1 mile in width at the water surface. Such a reservoir, however, would flood the villages of Central Bridge, Schoharie, Middleburg, Fultonham, and Breakabeen, besides several small ones. Middleburg and Schoharie are large towns, the former being the county seat of Schoharie County. The Schoharie Valley

Railroad now passes through the central part of the valley and would require removal. Taking into account the large expense of the necessary readjustments of towns and the railway, it has not seemed worth while to study this project in detail, the more especially since the control to be obtained would be only moderate. A general idea of the possibilities of Schoharie Creek storage may be obtained by reference to the Schoharie quadrangle map, as per the United States Geological Survey, recently issued.

On West Canada Creek the valleys are mostly narrow and only a moderate storage could be obtained with high dams. There is a possible site just above Prospect, where rock appears in the bed of the stream. The narrowness of the valley, however, and the consequent small storage to be gained have seemed to render it undesirable to make extended studies at this place. The other locations in West Canada Creek Valley are relatively small and unimportant, although a moderate amount of storage could be made by raising the water surfaces of some of the numerous lakes and ponds. As a perfectly general estimate, not based on detailed data, it is considered that a dam about 100 feet in height a short distance above Prospect would store, perhaps, about 2,000,000,000 cubic feet.

On East Canada Creek the valleys are all narrow, not affording any opportunity for storage on a large scale, and any storage to be made in this catchment area must necessarily be on the numerous small lakes and ponds of the region, which, however, could only control a relatively small part of the run-off.

The foregoing presents in small space the main reasons why it has not seemed desirable to investigate a system of flood reservoirs on the tributaries of Mohawk River. The conditions on Upper Mohawk catchment area are such that the area controlled by any practicable system of reservoirs would be, in comparison with the whole, relatively small, and, without going into the details, it has seemed to the author probable that the effect would not justify the expense. From this point it appears preferable to construct a canalized river of such dimensions and with sufficiently liberal spillways to take care of maximum floods, whatever they may be.

General studies were also made as to possibility of diverting a portion of the flood flow of Mohawk River above Little Falls from the canalized channel through independent channels to one side, one such flood channel delivering at Little Falls and the other through the valley of Wood Creek west of the west end of the proposed summit level, the object of this latter channel in Wood Creek Valley being chiefly to divert from the ship canal flood flows of Upper Mohawk above Rome. Study showed, however, that, owing largely to the flatness of the valleys, the difficulties of handling flood flows in independent channels would be greater than if handled in the canalized channel.

ESTIMATE OF SUMMIT LEVEL WATER SUPPLY.

The proposed summit level of the Oswego-Mohawk route, with water-surface elevation of 415 feet above tide, extends from station 3039 of the main deep-waterways survey to station 3758, a distance of 71,900 feet (13.62 miles). The water surface for a 30-foot channel in earth is 334 feet wide, and for a 21-foot channel, 310 feet. The area of cross section of 30-foot channel is 8,000 square feet and for 21-foot channel, 5,500 square feet.

The tributary streams may be relied upon to keep the main channel full during the winter season, even under the most adverse conditions of winter drought. Filling in the spring may be, therefore, left out of the account, and the problem is accordingly simplified to a determination of the quantity required to supply lockages, evaporation, percolation, gate-and-sluice-leakage losses, and wastage. The locks at the ends of the summit level are to be 740 feet in length by 80 feet wide, with lifts of 20 feet. Also, at Little Falls, 129,460 feet (24.52 miles) east of the east end of the summit level, there are to be duplicate sets of tandem locks, with total lift of 43 feet, the lock chambers being 740 feet long by 60 feet in width.

The West Canada Creek, which has a catchment area above its mouth of 569 square miles, flows into Mohawk River at Herkimer. The several small streams known as Crane Creek, Reels Creek, Knapp Brook, Budlong Creek, Sterling Creek, Bridenbacker Creek, and adjacent territory lying on the north side of Mohawk River and between Herkimer and the east boundary of Nine-Mile Creek area, have a catchment area of 86 square miles. To the east of Herkimer, on the north side of Mohawk River, Beaver Brook and adjacent territory have 15 square miles, while on the south side, between Utica and Little Falls, Ballou Creek, Factory Creek, Ferguson Creek, Meyer Creek, Steele Creek, Fulmer Creek, and adjacent territory have a catchment area of 139 square miles. The total catchment area tributary to the main deep waterway between Little Falls and east end of the summit level is therefore (569+86+15+139) = 809 square miles. This area may be expected to yield from 150 to 200 cubic feet of water per second in a dry time, which will, it is believed, be ample for the various losses and small additional lockage requirement on the reach of canal between the east end of the summit level and the double locks at Little Falls.

According to data furnished by your Board, the annual traffic is assumed at 25,000,000 tons, with an assumed tonnage per lockage for 30-foot channel of 3,000 tons and for 21-foot channel a tonnage per lockage of 2,500 tons. Let us first estimate the water consumption for the 30-foot channel.

The question of water supply of canals has been so fully discussed elsewhere as to make it impossible to add very much thereto at this time. So far as the United States is concerned, experience on Erie

Canal in the State of New York is the most extensive of any. Inasmuch as the author has given fairly full citations of Erie Canal data in the report on the water supply of the western division of the Erie Canal, to be found in the Annual Report of the State Engineer and Surveyor of New York for 1896, as well as in Water-Supply and Irrigation Paper, No. 25, of the United States Geological Survey—Water Resources of the State of New York—it has been deemed unnecessary to especially elaborate the question here. Indeed, the present case is so far beyond precedent as to compel discussion on somewhat different lines than any hitherto followed.[1]

Omitting, then, the usual preliminary general discussion, we have, with the foregoing data of annual traffic and tonnage per lockage, a total lockage per year of 8,333; add the usual 50 per cent for two ends of summit level, 4,167, whence the total number of lockfuls of water becomes 12,500.

Assuming 222 days of navigation, we have the following: Volume of one lockful=

$$(740\times 80\times 20)=1,184,000 \text{ cubic feet.}$$

For mean water supply per second we have—

$$\frac{12,500\times 1,184,000}{222\times 24\times 3,600}=772 \text{ cubic feet.}$$

Or, for even figures, we may place the lockage requirement at 800 cubic feet per second. The foregoing quantity of 800 cubic feet per second expenditure of water for lockages is based upon absolutely uniform distribution of vessels, both as to direction and season. As a modifying factor we should take into account these elements:

(1) Since the feeder has no storage in the vicinity of the main canal any draft in excess of the mean quantity must be drawn from the main channel itself.

(2) As a broad proposition, there will be a tendency to more lockages in daylight than at night.

(3) In the spring of the year, on account of the preponderance of the grain trade, the larger proportion of movement will probably be, for a time, from west to east. At other seasons there are likely to be times when the traffic will be in excess in one direction. The estimate of one and one-half lockfuls of water for each vessel passing the summit is based on uniform distribution of the traffic, otherwise two lockfuls per vessel passing is required. The proper addition to the lockage requirement on account of such irregularity can not be definitely determined until one has statistics of the actual movement covering a series of years. In the absence of such the foregoing may

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[1] Reference may be made to the annual reports of the Chief of Engineers for numerous discussions of the general question of canal water supply, formulæ for same, etc. See the several indexes to these reports.

be pointed out as a reason why the lockage requirement should be properly placed somewhat larger than the theoretical figure.

Table No. 12 gives evaporation from a water surface, as observed at the Mount Hope reservoir of the Rochester waterworks, from 1892 to 1898, inclusive. For the navigation months April to November, inclusive, evaporation ranges from 1.33 inches in November, 1897, to 6.85 inches in July, 1898. The water surface of the proposed summit level is so small as to make evaporation, even in the maximum month, hardly worth taking into account. At 6.85 inches for the month the evaporation on the summit level becomes, roundly, 5 cubic feet per second. In order to give evaporation some value in the estimate of total water supply we will take it at from 5 to 10 cubic feet per second.

The author knows of no rational method of estimating percolation loss for a canal under the conditions which exist in Mohawk Valley. The drainage is all toward the valley, and at first thought it might appear that percolation was a negligible quantity. However, if we consider that the total water supply, as estimated for the summit level, takes into account the entire yield of the catchment area tributary to the main channel, and further consider that the channel, as located, has its water surface for a considerable distance several feet above the ordinary water plane of Mohawk River and Wood Creek in their natural condition, we may conclude that percolation ought not to be entirely neglected, more especially because the soils in the Mohawk bottom are open and porous, and without some method of consolidation of the natural soils, which does not now occur to the author, can be devised there is likely to be considerable loss from percolation. By way of showing the relation of water surface of the summit level to ordinary water levels in Mohawk River and Wood Creek the following data are cited:

At a distance of 17,000 feet east of Rome the ordinary water surface of Mohawk River is at elevation of 415, or the same as water surface of the summit level; 24,000 feet east of Rome it is 413; 32,000 feet east it is 408; 41,000 feet east, 404; and 47,000 feet east, 401.

At 17,500 feet west of Rome the ordinary water surface of Wood Creek is at 414, or 1 foot lower than the summit level; at 21,500 feet west of Rome it is 408; and at 25,500 feet west, 398.

The author has no way of demonstrating the proposition, although it seems clear enough to him, that with an open, porous soil the percolation from the canal at points where the summit level is raised somewhat above the ordinary water level of Mohawk River and Wood Creek will be considerable. The porous soils of these valleys will take up water like a sponge, making considerable areas from which, due to a luxuriant vegetation, the summer evaporation may be as much as 60 inches over the actual ground area affected. The land damage on these areas will be considerable and should be taken into account in the estimate. In dry years, with a total rainfall from

June to November, inclusive, of from 8 to 12 inches, the amount required to keep up this great evaporation must come by percolation from deep waterway channel. If we assume an area of 10 square miles as affected, the amount of water required to keep up constant evaporation, on the basis of 60 inches for the navigation season, would be nearly 80 cubic feet per second, or, even if we consider the area affected as not exceeding 5 square miles and take into account the loss into the old water channels, it seems rational to allow percolation from summit level of 75 to 100 cubic feet per second.

Leakage at gates and structures is a very uncertain element. Under ordinary conditions the gates ought to be worked without very much leakage. The data furnished by your Board indicates a probable loss from this source of perhaps 60 to 80 cubic feet per second.

A considerable amount of power will be required at each lock for operating gates and for electric light at night. A conservative allowance for this purpose seems to be from 20 to 25 cubic feet per second at each end of summit level, or a total of 40 to 50 cubic feet per second.

On Erie Canal considerable time is saved by flushing boats out of the locks on to the lower levels by letting water through the gates from above. The author does not understand, however, that this practice is specially applicable to locks passing boats carrying their own power. In order to accommodate local traffic it is probable, even though deep waterways should be constructed on substantially the lines now under consideration, that Erie Canal would be maintained on its present line from near Rome to Buffalo. Independent of other considerations, this would lead to considerable traffic on deep waterways in the way of barges, timber rafts, and fleets of canal boats, the handling of which will probably be more or less expedited by a reasonable use of water for flushing out on to the lower levels. As a matter of judgment, purely, this item has been placed at from 50 to 60 cubic feet per second, although by the use of mechanical arrangements for doing this work the quantity of water could be materially reduced, flushing being in any case an uneconomical method of applying force.

In order to pass the large flood flows of Upper Mohawk without great fluctuation of the water surface, it will be necessary to provide from 2,000 to 2,500 linear feet of spillway at each end of the summit level, and over which, whenever there is any interruption of uniform distribution of lockages, there must necessarily be considerable waste. Taking into account the actual water-surface area of the summit level of (71,900 × 334) = 24,014,600 square feet, and assuming an inflow of 1,300 cubic feet per second, without any outflow, the increase in depth per hour becomes 0.19 foot, or in three hours the increase in depth would become 0.58 foot. However, if there were no lockages for three hours, the depth would not increase as rapidly as this because of the leakage at gates and sluices and wastage on the spillways. In order to illustrate this matter we may consider the following tabulation, in which the heads are given in inches and feet. The coefficient used for the computation, as derived from Bazin's experiments, is applicable to a flat-crested, or nearly flat-crested, weir from 6 to 7 feet wide. The quantity of discharge, Q, in cubic feet per second, is given per lineal foot of crest and also for 2,500 feet of crest.

Head.		Coefficient.	Q in cubic feet per second per lineal foot of crest.	Q for 2,500 feet of crest, in cubic feet per second.
Inches.	*Feet.*			
1	0.083	2.20	0.053	133
2	0.167	2.20	0.150	375
3	0.250	2.35	0.294	785
4	0.330	2.42	0.459	1.148
5	0.417	2.47	0.665	1,663

Referring to this tabulation, it appears that when the water rises to a depth of only 1 inch on such a crest, the discharge over 2,500 lineal feet would become 133 cubic feet per second, while for 2 inches depth it becomes 375 cubic feet per second, and for 3 inches, 735 cubic feet per second, and so on up to 1,663 cubic feet per second for a depth of 5 inches. However, the wastage would be less than these figures indicate at first glance, because of the outflow from leakage and the wastage over the crest. A problem of this nature has been discussed at length in the author's report on Genesee River storage, to be found in the Annual Report of the State Engineer and Surveyor of the State of New York for the fiscal year ending September 30, 1894, and reference may be made to pages 390 and 391 of that report for formulæ and numerical example.[1] Inasmuch as the solution of the present case is precisely like the case there cited, it has not seemed worth while to repeat the computation here. It is sufficient to say that, applying the reasoning there given, it is shown that under the actual existing conditions of the proposed deep waterways summit level, whenever there is an interval of two or three hours without lockages, the wastage over the long spillways at the ends of the level will amount to several hundred cubic feet per second. This quantity may probably be reduced somewhat by the use of flashboards, to be set in place and taken off as necessary, although, in view of the sudden flood rises of Mohawk River and consequent necessity for removing the flashboards frequently, the author can not but think that such remedy will be somewhat unsatisfactory. The safer way, without doubt, is to provide a liberal wastage requirement. On this basis the author has assumed from 150 to 250 cubic feet per second. Bringing these several items of summit water supply together we have the following:

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[1] The same problem is also discussed, pp. 722-724, of the Annual Report of the State Engineer and Surveyor for 1896.

	Cubic feet per second.	
(1) Lockages	800	800
(2) Evaporation	5 to	10
(3) Percolation	75 to	100
(4) Leakage at gates, etc	60 to	80
(5) Power and electric lights	40 to	50
(6) Flushing out canal boats, barges, and timber rafts	50 to	60
(7) Wastage at spillways	150 to	250
Total	1,180 to	1,350
(8) Feeder losses	300 to	600
Final total	1,480 to	1,950

As a conservative summation of this part of the discussion the author has assumed 1,600 cubic feet per second, which includes the feeder losses, as the proper basis of computing draft from reservoirs, providing, however, enough contingency in the storage to cover the maximum draft, should it ever be required. As a main reason why we may take the quantity of the water supply somewhat less than the maximum indicated by the foregoing figures, it may be pointed out that the summit-level locks, while 740 feet in length between the main gates, are further provided with two intermediate sets of gates, dividing the lock chamber into lengths of 500 and 240 feet. The use of these shorter prisms for locking small vessels may be expected to result in considerable saving of water, but just how much can not be determined in the absence of specific statistics of lockage.[1]

Proceeding on similar lines of discussion for water supply of supply level for 21-foot depth of canal, we reach the following result:

	Cubic feet per second.	
(1) Lockages	575	575
(2) Evaporation	4 to	8
(3) Percolation	75 to	100
(4) Leakage at gates, etc	50 to	60
(5) Power and electric lights	35 to	47
(6) Flushing out boats	50 to	60
(7) Waste at spillways	150 to	250
Total	940 to	1,100
(8) Feeder losses	275 to	500
Final total	1,215 to	1,600

Taking an approximate mean of the foregoing final totals, we may fix upon 1,400 cubic feet per second, including feeder losses, as the proper supply for a 21-foot canal.

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[1] Additional reasons for taking the feeder losses at less than indicated in the foregoing tabulation are given in the chapter on Discussion of proposed Black River feeder.

WATER SUPPLY FOR LOW-LEVEL SHIP CANAL.

The detailed data of this project not having been furnished to the author, the following discussion must be taken as an approximation merely.

The project for a low-level canal includes cutting through the Rome ridge from the low-water level of Oneida Lake (368.50 + T. W.) to Mohawk Valley, at Little Falls. In order to obtain a water supply for operating the locks at either end, etc., it is proposed to make a storage on the surface of Oneida Lake and the connecting canals to the depth of 7 feet. The locks at the ends are assumed to have 20-foot lifts.

Evaporation loss will be that due to the surface of Oneida Lake, as well as of the canal from the summit-level lock below Brewerton to Little Falls. Percolation, however, aside from leakage of dikes around west end of Oneida Lake, will be nothing.

The fluctuation of Oneida Lake will be taken to occur between elevations 368.5 and 375.5, for which elevations we may assume a mean area of about 85 square miles. We have, then, the approximate water surface of lake and canal between locks equal to 88.7 square miles, from which the evaporation for the navigation months, April 15 to November 30, inclusive, may be taken on the basis of the means of the Rochester measurements, at 29.92 inches, or, as these figures are means, we may say 30 inches, which equals 2.5 feet. This leaves an effective storage on Oneida Lake and the canal of 4.5 feet over 88.7 square miles. The total storage of 7 feet on 88.7 square miles would be 17,309,699,000 cubic feet. The effective storage of 4.5 feet depth would, however, only be 11,127,663,000 cubic feet.

If we assume the run-off of the growing and replenishing periods of streams tributary to Oneida Lake in an ordinary dry water year at 4 inches, we have an addition to the effective storage of 11,756,000,000 cubic feet. The total available storage becomes, then, 22,885,000,000 cubic feet, equivalent to 1,190 cubic feet per second for 222 days.

We will now estimate the water supply required for a low-level canal 30 feet in depth. Inasmuch as evaporation has been allowed for in the preceding discussion, we may leave that out of the account. We will also include only a small percolation allowance for leakage through the dikes near Brewerton.

	Cubic feet per second.	
(1) Lockages	800	800
(2) Percolation	10 to	20
(3) Leakage at gates, etc	60 to	80
(4) Power and electric lights	40 to	50
(5) Flushing out canal boats, barges, and timber rafts	50 to	60
(6) Wastage at spillways	40 to	90
Total	1,000 to	1,100

With the large storage area of Oneida Lake, wastage at spillways ought not to exceed about 40 to 90 cubic feet per second, and may be even less. In any case, the preceding figures show that for ordinary years there would be a clear surplus of 90 cubic feet per second. Hence this item does not enter specially into the account.

We will assume that, with all contingencies, the larger quantity of the preceding tabulation—1,100 cubic feet per second—is the least figure to be used for water supply of low-level canal. Let us examine as to whether this supply can be obtained in an extreme minimum dry year. The quantity of 1,100 cubic feet per second amounts for 222 days to 21,100,000,000 cubic feet, which is equivalent to 7.25 inches on Oneida Lake catchment area of 1,265 square miles. Probably if we were to have such an extreme dry year, as has been shown to be possible in the chapter—Meteorology of New York and the Relation of Precipitation to Run-off—Oneida Lake catchment area by itself might not yield quite 7.25 inches. The entire Upper Mohawk area of 1,306 square miles above Little Falls would, however, be tributary to the canal, and by proper regulation a portion of its run-off could be stored on Oneida Lake, thus insuring an ample water supply for a low-level canal under the most adverse conditions and without resort to artificial reservoirs. From this point of view there is no reason for doubting the adequacy of the water supply for low-level canal under the most adverse meteorological conditions of which it is possible to conceive. The large storage of Oneida Lake would undoubtedly prove ample for all contingencies.

The preceding discussion having shown adequacy of water supply for low-level summit canal 30 feet in depth, it follows that supply of low-level canal 21 feet in depth is equally assured.

WATER SUPPLY FROM STATE RESERVOIRS ON THE MOHAWK-SUSQUEHANNA DIVIDE.

The water supply of the abandoned Chenango Canal included several reservoirs on the dividing ridge between Oriskany Creek and Chenango River drainage and which, since the abandonment of Chenango Canal, have been retained as feeders for Erie Canal, water therefrom being delivered into Erie Canal at Utica through the abandoned Chenango Canal. These reservoirs are situated in Madison, Eaton, Nelson, and Lebanon townships in Madison County and include the following: Hatchs Lake, Eaton Brook, Bradley Brook, Leland Pond, Madison Brook, and Kingsley Brook reservoirs. Their main characteristics and storage capacity in cubic feet are shown by the following:

Name of reservoir.	Distance to Erie Canal.	Average area.	Average depth.	Storage capacity.
	Miles.	*Acres.*	*Feet.*	*Cubic feet.*
Hatchs Lake	36	......	10	58,370,400
Eaton Brook	38	214	50	553,212,000
Bradley Brook	35	......	25	145,928,000
Leland Pond	25	150	8	59,287,040
Madison Brook	29	235	45	460,647,000
Kingsley Brook	33	......	20	98,445,000
Total storage	......	......	......	1,375,888,040

Measurements of the run-off of Eaton and Madison brooks, on which are situated the Eaton Brook and Madison Brook reservoirs, were made by John B. Jervis in 1835. The catchment area of Eaton Brook is stated at 10.6 square miles and that of Madison Brook at 9.4 square miles. The run-off of Eaton Brook from June, 1835, to December of that year, inclusive, was 191,528,020 cubic feet, the rainfall for the same months being 19.82 inches. The run-off of Madison Brook from January, 1835, to December of that year, inclusive, was 383,986,420 cubic feet, the rainfall of the period being 35.26 inches. The run-off of the year 1835 from the Madison Brook catchment area therefore becomes 15.83 inches. We may safely assume that in 1835 there was considerably more timber on these catchment areas, and that therefore the run-off for a given rainfall was larger then than now.[1]

Referring to the foregoing table it is seen that the storage capacity of Eaton Brook reservoir is given at 553,212,000 cubic feet and Madison Brook at 460,647,000 cubic feet, the sum of the two being, roundly, 1,000,000,000 cubic feet. The entire run-off of these two catchment areas, of which the total is 20 square miles, did not include in 1835 more than 770,000 cubic feet. In an extreme dry year the yield of these areas will not exceed, under present conditions of forestation and cultivation, 40 to 50 per cent of the stated yield in 1835. In view of Genesee River record, as well as gaugings of Oriskany, Saquoit, and other creeks issuing from south side of Mohawk-Oneida Valley, we probably are not justified in assuming more than about 7 inches over the catchment area as total run-off of these streams in a year of minimum flow. These reservoirs have therefore very little value for feeding the main deep waterway, although if kept full they may be of some use for emergency supplies. Hence it has been deemed best to omit them from consideration as part of the permanent supply, but inasmuch as in case of building a deep waterway on the Oswego-Oneida-Mohawk-Hudson routes, such construction would undoubtedly be preceded by the abandonment of the Mohawk Valley section of Erie Canal, and consequently Erie Canal reservoirs would be available for deep waterway supply. The suggestion is made, therefore, that these reservoirs be taken over in the final arrangements with the State of New York and held for emergency purposes only, the channels leading to the head waters of Oriskany Creek being sufficiently enlarged to permit of passing, if necessary, something like 500 cubic feet per second, in this way materially assisting the water supply of main deep waterway in case of temporary interruption of supply from the usual sources. A small amount has been included in the estimates to cover the cost of necessary enlargement of the feeder channels, which at present are somewhat restricted.

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[1] For detail of the measurements of run-off of Eaton and Madison brooks, as made by John B. Jervis in 1835, see Water Supply and Irrigation Papers of the United States Geological Survey, No. 24; Water Resources of the State of New York, by George W. Rafter, pp. 67 and 68, where full reference to Mr. Jervis's original reports may be found.

DESCRIPTION OF BLACK RIVER.

The Black River rises in the western part of Hamilton County, whence it pursues a southwesterly direction, passing across Herkimer and into Oneida County. It then turns and runs northwest through Lewis County, after which its course is westerly across Jefferson County to Black River Bay, at the eastern extremity of Lake Ontario. The catchment area of Black River at various points, and of its main tributaries, are as follows:[1]

	Square miles.
Black River, at mouth	1,930.2
At Watertown (Remington's dam)	1,891.7
At Watertown (waterworks dam at Huntingtonville)	1,888.6
At Black River village	1,868.9
At site of Rawson's dam (4 miles below Carthage)	1,824.1
At Carthage	1,812.2
Above mouth of Moose River	463.0
Forestport	268.0
Beaver River, at mouth	337.5
Beaver River, at Beaver Falls	322.3
Moose River, at mouth	415.5
Moose River, at Agar's mill	407.3
Deer River, at mouth	102.0
Deer River, at Deer River village	100.8
Woodhull Creek	108.4
Otter Creek (one-half mile above mouth of creek)	63.0
Independence Creek, at mouth	98.8
Independence Creek (3 miles above mouth)	93.2

The length of the river, measured along its course from its mouth at Black River Bay to the head waters, is 112 miles.

The section drained by the upper river in Herkimer and Hamilton counties is a rugged, mountainous region, with numerous lakes, a number of which have been utilized by the State of New York as storage reservoirs to compensate for water taken for the supply of Black River and Erie canals.

The extreme head waters of the main river are Canachagala Lake, North Lake, and South Lake. Other lakes on the head waters of the main river are Woodhull, Little Bisby Chain Lakes, Little Woodhull, Chub, Long, White, and a number of others. The chief tributaries of Black are the Moose and Beaver rivers, both of which rise in Hamilton County and flow across Herkimer into Lewis County. The principal lakes at the head of Moose River are Two Sisters, Pigeon, Big Moose, Second, Cascade, Fulton Chain, Lime Kill, and Little Moose lakes. The principal lakes at the head waters of the Beaver River are Lakes Lila and Frances, Josephine Lake, Nehasane, Big Rock, Little Rock, Salmon, Loon, and Twitchell lakes and others.

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[1] These data are repeated from p. 577 for convenience of reference.

Other smaller tributaries of Black River are Black Creek, Little Woodhull Creek, Big Woodhull Creek, Crystal Brook, Otter Creek, Independence Creek, Crystal Creek, Swiss Creek, Moose Creek, Sugar River, Whetstone Creek, Roaring Creek, Mill Creek, Deer River, and other small streams. The following gives the elevation, in feet, of the main points on Black River above tide water, according to the best available information:

	Feet.
At mouth	247
Watertown, west line of city	370
Watertown, at head of falls	492
Felt's mills, crest of dam	563
Carthage, at foot of rapids	669
Carthage, crest of State dam	724
Lyons Falls, at foot	733
Lyons Falls, crest of State dam	802
Forestport, crest of State dam	1,129
North Branch reservoir	1,821
Chub Lake	1,599
Woodhull reservoir	1,854
South Branch reservoir	2,019
Moose River, at mouth	802
First Lake, Fulton Chain	1,684
Second Lake	1,684
Third Lake	1,685
Fourth Lake	1,687
Fifth Lake	1,691
Sixth Lake	1,760
Seventh Lake	1,762
Eighth Lake	1,803
Little Moose Lake	1,772
Big Moose Lake	1,787
Beaver River, at mouth	724
Beaver River, at Number Four	1,436

EARLY WATER POWER AND MANUFACTURING PROJECTS ON BLACK RIVER.

Precise knowledge of the region drained by Black River is almost entirely confined to the present century. So little was known of its geography that in a statistical work, Winterbotham's View of the American United States, published in 1796, it is stated that Black River is said to rise "in the high country near the sources of Canada Creek, which falls into the Mohawk River and takes its course northwest and then northeast until it discharges into the Cataraqui or Iroquois River not far from Swegauchee; it is said to be navigable for bateaux up to the lower falls, 60 miles." That is to say, Winterbotham understood Black River to be navigable either to Carthage or possibly Lyon Falls, the misapprehension probably having grown out of the accounts given by hunters and trappers of the long, nearly level stretch of about 40 miles between Carthage and Lyon Falls. The Black River is not represented on any of the early French or English maps of the region.[1]

Surveys of Watertown Township were made by Benjamin Wright, who was later chief engineer of Erie Canal, in 1796. His report may be considered the beginning of something like accurate knowledge of the region. In regard to Watertown Township he states therein that "township No. 2, on Black River, is situated about 3 miles from the mouth of the river. This river is navigable for bateaux about 1¾ miles, but yet with considerable difficulty it may be ascended 2½ miles. * * * There are excellent mill seats along Black River, where they are noted on the map, and many more, which it is impossible to note with certainty, as the river the whole distance on the town is very rapid except at the northeast corner for about three-quarters of a mile. The river is very rocky along the whole distance and appears to be a bed of limestone rocks."

Settlements began in Watertown Township on the site of the present city of Watertown, in March, 1800, three families having arrived at that time, and these were the only ones remaining during the ensuing winter, although many visited Watertown during the summer of 1800 on prospecting tours, who subsequently settled there. The precise history of the region began, therefore, in the fullest sense, with the nineteenth century.[2]

According to Dr. Hough, the name of Watertown Township was doubtless suggested by the extraordinary amount and convenience of its water power, for which, Dr. Hough says, it will compare favorably with any place in the State. "To this cause may be mainly attributed its early and rapid growth and the superiority in wealth and business which it enjoys far beyond any other place in the county."

Watertown is the county seat of Jefferson County. According to the census reports the population of the township in 1800 was 119; in 1810 it was 1,841; in 1820, 2,766; in 1830, 4,768; in 1840, 5,027; in 1850, 7,201; in 1860, 7,567. In 1869 the city of Watertown was erected from territory taken from the townships of Pamelia and Watertown. In 1870 the population of the city of Watertown was 9,336, the population of the township being in that year 1,373; in 1880, the population of the city was 10,697, and the township 1,264; and in 1890 the city was 14,725, and the township, 1,215. The township of Pamelia had a population in 1860 of 2,789, and in 1870, 1,292, the difference in this case evidently being chiefly due to the absorption of a portion into the city of Watertown. As in the case of Watertown Township, however, the population of Pamelia has been gradually lessening during the last two census decades. In 1880 it was 1,143, and in 1890,

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[1] See preface to A History of Jefferson County, by Franklin B. Hough, Watertown, 1854.

[2] For early history of settlements on Black River see Hough's history.

1,104. Plotting a population curve for the city of Watertown with the data of the censuses of 1870, 1880, and 1890, we learn that the probable population in 1900 will be 22,800, and in 1905, 29,300. Since its incorporation as a city the development of the manufacturing industries of Watertown has been very rapid.

In addition to Watertown the other chief water-power points of the Black River Valley are Dexter, Brownville, Black River Village, Felts Mills, Great Bend, Carthage, Lyons Falls, and Port Leyden. There are also extensive water powers on the Beaver and Moose rivers, tributaries of the Black, but which, aside from Beaver Falls, we are not specially concerned with in this present report, nor are we specially concerned in this report with water powers on the main stream above Lyons Falls.

The chief object of this chapter is to present a concise view of the relation which the development of Black River water power has had to the growth of the region as a whole, such discussion leading to a broad consideration of the effect of materially interfering with the development of the manufacturing interests. We will endeavor, in short, to discuss the economic proposition involved in seriously interfering with the productive industries of an extensive manufacturing community.

Without going into an extended account of the early manufacturing establishments of the Lower Black River, we may still give enough to show that manufacturing has always been a leading occupation of the Black River Valley population.

DEXTER.

At Dexter manufacturing improvements were begun in 1811 by Jacob and John Brown, who built a dam across the river, which, however, was carried away by high water the next season. It was replaced and in 1813 a sawmill put in operation. In 1826 John E. Brown erected a gristmill. James Wood & Sons began the erection of a woolen factory about 1830, and in 1836 the Jefferson Woolen Company was formed with $100,000 capital for the construction and operation of a woolen mill. The mill was built in 1837, but the investment soon proved a failure. Subsequently the mill was operated by private parties.

BROWNVILLE.

Jacob Brown erected a sawmill at Brownville in 1800 and a gristmill in 1802, but it was not until 1806 that a dam was built across Black River at this place. In 1814 a company was formed to construct and operate a cotton mill at Brownville with a capital stock of $100,000. This mill was operated with varying fortunes until about 1860. In 1820 a woolen factory and various other enterprises were inaugurated.

WATERTOWN.

At Watertown the first dam was built across the south channel at Beebee's Island by Jonathan Cowan in 1802 to operate a gristmill. In 1805 Coffeen's dam was built at the lower falls and about 1814 the dam at Soules Island was constructed, but it was not until 1835 that the large dam across the north channel at the head of Beebee's Island was built. According to Dr. Hough, these four original dams of 1802, 1805, 1814, and 1835 were still standing in 1854, but the flood of 1869, at any rate, worked sad havoc with some of them. The present stone dam across the south channel of Beebee's Island was constructed in 1869.

The first important manufacturing industry other than the grist and saw mills was Caswell's paper mill, started in 1808. This mill was the forerunner of the paper industry on Black River The machinery consisted of a small rag machine, carrying about 150 pounds of rags; two or three potash kettles, set in a brick arch, for boiling rags and preparing sizing; one vat for making the paper sheet by sheet, and a rude standing press to squeeze the water out of the pack. After pressing, the sheets were taken from the pack and hung on poles to dry, and if intended for writing paper were afterwards dipped in sizing and again dried. The entire process was worked without the use of steam or bleaching material. As a substitute for calendering the sheets were pressed between boards. The output was about 150 pounds of paper per day. This mill continued to make paper until 1833, when it was sold to Knowlton & Rice, who had begun the manufacture of paper on a more extended scale in 1824. This firm continued to be the only paper manufacturers on Black River until 1854, in which year I. Remington & Sons fitted up a mill with four rag machines and an 84-inch Fourdrinier machine. This mill made newspaper only and had a capacity of 3 tons per day. From these small beginnings have grown up the extensive paper industries of Black River, as shown by the accompanying statistics of manufacturing on that stream as it existed in 1898.

As already stated, the first manufacturing industry in the village of Watertown was the primitive gristmill built by Jonathan Cowan in 1802. This was the forerunner of extensive flouring mills at this place later on. The Bailey & Clark and Coffeen mills, of small capacity, were both built at some date previous to 1812, but it was not until 1835 that Joseph Sheldon and Philo C. Moulton built the Union Mills, with a capacity of 200 barrels of flour per day. The Excelsior Flour Mills were erected by Moulton & Simons in 1845. This mill is now operated by the A. H. Herrick & Son Company, incorporated in 1895 with a capital of $50,000 by A. H. and E. W. Herrick and George G. Lee. This mill has a capacity of 100 barrels of wheat flour and 100 barrels of buckwheat per day. The Jefferson Flour Mills were erected in 1855 and operated until about 1880, when the property was sold to Knowlton Brothers and converted into a pulp mill. The Crescent Flour Mills were built by Fuller, Isdell & Willard in 1870 and succeeded the old Phœnix Mill of earlier years, which was carried away by the flood of 1869. Crescent Mill now has 19 stands of rolls, a daily capacity of 200 barrels of flour. The Electric Mill, built in 1895, is operated by electrical power derived from wheels of Taggart Brothers Company. It is used exclusively for grinding feed, and has a capacity of 250 barrels per hour.

In the early days of Watertown several tanneries were operated, the first industry of this character having been established in 1808, in which year C. McKnight set up a saddle and harness business and prepared and tanned his own leather. Jason Fairbanks established an extensive tannery in 1823, although he had done tanning on a small scale for several years previous thereto. Holt & Beecher established a tannery at some date previous to 1830, which remained in operation until carried away by the flood of 1856. Several other tanneries were started at different times, but with the changed conditions of business they have all passed away. These tanning establishments all used power from Black River for grinding bark.

Beginning with the time of the war of 1812 to 1815, the manufacture of cotton and woolen goods became an important industry on Black River, the Black River Cotton and Woolen Manufacturing Company having been incorporated in 1813 with a capital of $100,000. In 1827 Levi Beebee erected the Jefferson Cotton Mills, equipped with 10,000 spindles and said to have cost about $200,000, being at that time one of the largest cotton mills in the State. This mill was destroyed by fire in 1833. Watertown Cotton Mills Company was incorporated in 1834 with a capital of $100,000. This company ran 50 looms, but after several years, the business becoming unprofitable, it was discontinued. The Hamilton Woolen Mills Company, which developed the water power at the head of Sewall's Island, was established in 1835 with a capital of $100,000. The dam and factory were built in 1836. In 1842 the plant was purchased by the Black River Woolen Company, which built a new mill and carried on a fairly successful business until 1841, when the plant was burned. Subsequently the business was revived by Loomis & Co., who employed about 70 hands in the manufacture of woolen goods. Other manufacturing enterprises of this class were the Watertown Woolen Company and the Watertown Woolen Manufacturing Company. The cotton and woolen manufacturing establishments on Black River are now all out of existence.

The machine shop of Nathaniel Wiley, established about 1820, was the first iron-manufacturing establishment at Watertown. In 1823 George Golding established a machine shop on Sewall's Island, making mill gearings, factory machines, and an occasional steam engine. This shop ultimately led to the founding of the present Bagley & Sewall Company, which is one of the largest establishments of its kind in the northern part of the State, employing about 125 hands, chiefly in the manufacture of paper-mill machinery. The Watertown Steam Engine Company has grown out of a small business established by Hoard & Bradford in 1851. These works employ about 225 men and manufacture high-speed, direct-acting engines, stationary and portable, and agricultural engines and boilers of all kinds. The New York Air Brake Company, which is stated to be the largest manufacturing industry at Watertown, dates back to 1861. The foundry of this company uses water power from the Black River.

A large number of other manufacturing establishments have been established at Watertown, taking water power from Black River, as, for instance, the Union Carriage and Gear Company, Watertown Brass and Manufacturing Company, Watertown Thermometer Company, the Elwood Silk Company, Harmon Machine Company, and the H. H. Babcock Company, and others, as may be determined by reference to the accompanying table of water power in use on Black River in 1898. The H. H. Babcock Company is one of the leading carriage manufacturing industries of the State. When working at full capacity this company employs about 175 hands.

BLACK RIVER VILLAGE.

A sawmill was built at this place in 1806, which was carried away by high water and rebuilt the next year. A gristmill was erected in 1810 and another sawmill in 1815. In 1839 David Dexter founded an extensive chair factory. Other early industries were Poor's chair-stock factory and Wilcox coffin and casket works, which have, however, given way to more recent enterprises. Various other milling industries have been operated at this place at various times. The industries now established at Black River village are shown by table No. 128.

FELTS MILLS.

A dam was constructed across Black River at this place in 1821, and in 1822 what is known as the old stone mill, which still stands, was erected. It has not been operated for the last ten years. Large sawmills were erected by John Felt about 1824. The Taggart Paper Company, which is now the only industry using water power at Felts Mills, erected its plant in 1889.

GREAT BEND.

A dam was constructed across the Black River at this place in 1806 and a sawmill built, which was soon carried away by high water but at once replaced. Between 1815 and 1824 the place developed a number of milling enterprises, which are not specifically described in the early history. The large mill of the Taggart Paper Company is now the only water-power industry at this place.

CARTHAGE.

At Carthage we have what are known as the long falls of Black River, the river falling at this place 55 feet vertically in a distance of 4,600 feet. The first water-power establishment was David Coffeen's gristmill, erected on the west bank of the river in 1806, power therefor being furnished by a wing dam extending diagonally up the stream from the mill. A forge, operated by water power was built in 1816 on the east side of the river, and Coffeen's dam extended entirely across in order to furnish power. A blast furnace taking power from the river was built in 1819. A nail factory was erected in 1828.

In 1830 a tannery was erected on what is known as Tannery Island. A gristmill was built on Guyot's Island in 1838. Since that time there have been in operation on this island a forge, a rolling-mill, a gristmill, nail works, ax factory, broom-handle works, furniture factory, carding mill, and general repair shops. The large rolling mill and nail factory of Hiram McCollom was begun in 1845, who also built a foundry on Furnace Island in the same year. The foundry is still in operation.

The foregoing brief account of the early manufacturing industries of the lower Black River Valley, while only a skeleton, is still extensive enough to indicate how thoroughly manufacturing has been identified with the development of this valley from the very beginning. It is certainly clearly shown that the material prosperity of the region has been greatly advanced by Black River water power.

AS TO THE PERMANENCY OF BLACK RIVER RUN-OFF.

In view of the vast commercial interests in the proposed deep waterways, provided they are constructed and operated, the question as to permanency of Black River run-offs becomes one of considerable importance. In preceding chapters we have discussed the actually observed run-offs of Hudson River for the eleven years from 1888 to 1898, inclusive, as well as the observed run-offs of Black River from March, 1897, to May, 1899. We also give farther on a table showing the effect upon the proposed Black River reservoir of taking therefrom every day in the year 2,200 cubic feet of water per second, as compensation water to the stream, together with the taking of whatever may be necessary to furnish an adequate supply for summit-level canal. In the chapter On the Meteorology of New York and the Relation of Precipitation to Run-off it has been shown that, reasoning from precipitation data purely, it is quite possible there may occur a year when the run-off will be less than any thus far observed.

As regards maintaining the observed run-offs of the last eleven years, the conditions on Black River are, on the whole, reassuring. For a number of years the author has been gathering data as to the effect of forests in conserving stream flows, with the result of satisfying himself that it may be tentatively stated that forests do conserve and increase the run-off of issuing streams somewhat. The reasons for this conclusion are stated at length elsewhere and will not be gone into in this place.

In 1897 the New York State legislature passed An act to provide for the acquisition of land in the territory embraced in the Adirondack Park and making an appropriation therefor. Under the terms of this act a forest preserve board was created, which has, during the last two years, purchased large areas on the head waters of Hudson and Black rivers, etc. The limits of the Adirondack Park were defined by an act passed in 1893. Space will not be taken to describe the entire area included in Adirondack Park any further than to state that the western boundary has been made the line between Herkimer, Lewis, and Oneida counties. The south line is the south line of Hamilton County extended westerly to where the main Black River intersects the west line of Herkimer County. The area within Adirondack Park includes, therefore, the head waters of main Black River, with its two chief tributaries, Moose and Beaver rivers. It is expected that this entire area will in time, so far as the forests have been removed, be reforested and held as a permanent State reserve.

In order to show the relative proportions of virgin forest, culled area from which the merchantable timber has been removed (which, in the case of the Adirondack, is soft wood), the cleared area, and the water area for a considerable extent of the Adirondack region several of the topographical sheets of the United States Geological Survey have been taken and the areas of the different classes, as just detailed, colored in, the data used for this purpose being that gathered by the United States Geological Survey in the original preparation of the maps. The following are the figures derived from three sheets covering area either in or adjacent to the head waters of Black River, namely, Old Forge, Wilmurt, and Canada lakes sheets. The following tabulation shows that for these three topographical sheets the total area of virgin forest is 234.91 square miles; of culled area, 39.88 square miles; water area of lakes and ponds, 17.50 square miles; the total area included in the three maps is 651 square miles. The Remsen sheet, which covers area just in the edge of the great northern forest, shows 83.98 square miles of culled area and 133.01 of cleared area, the total of the sheet being 217 square miles. Farther to the north and west, in the vicinity of Carthage, Watertown, and in the lower part of the Black River basin, generally the cleared area is proportionately considerably larger than on the Remsen sheet. It is in many places substantially like the Schuylerville and Glens Falls sheets tabulated farther on.

BLACK RIVER.

Topographic sheet.	Virgin forest.	Culled area.	Cleared area.	Water area.	Total area.
(1)	(2)	(3)	(4)	(5)	(6)
	Sq. miles.	*Sq. miles.*	*Sq. miles.*	*Sq. miles.*	*Sq. miles.*
Old Forge	59.96	130.85	14.25	11.30	216.40
Wilmurt	4.75	186.23	24.38	1.95	217.30
Canada lakes	170.20	47.65	1.25	4.25	217.30
Total	234.91	358.73	39.88	17.50	651.00
Remsen	....	83.98	133.01	....	217.00
Final total	234.91	442.71	172.89	17.50	868.00

The foregoing four sheets are all of the topographical maps of the State, either including or in the vicinity of Black River catchment area, which are available at this date. We have, however, eight sheets either included in or in the vicinity of upper Hudson catchment area, as follows: Newcomb, Bolton, Paradox Lake, Elizabethtown, Mount Marcy, Schroon Lake, and Thirteenth Lake sheets. The statistics of these tables are given in the following tabulation:

HUDSON RIVER.

Topographic sheet.	Virgin forest.	Culled area.	Cleared area.	Water area.	Total area.
(1)	(2)	(3)	(4)	(5)	(6)
	Sq. miles.	*Sq. miles.*	*Sq. miles.*	*Sq. miles.*	*Sq. miles.*
Newcomb	....	186.10	24.50	4.90	215.5
Bolton	....	153	43.55	19.85	216.4
Paradox Lake	....	171.55	38.60	5.35	215.5
Elizabethtown	14.45	137.10	61.50	1.95	215
Mount Marcy	138.45	9.90	65	1.65	215
Indian Lake	10.40	193.40	6.15	6.45	216.4
Schroon Lake	1.10	172.10	35.80	6.50	215.5
Thirteenth Lake	.25	184.55	29.60	2	216.4
Total	164.65	1,207.70	304.70	48.65	1,725.7
Fort Ann	....	32.60	184.70	....	217.3
North Creek	....	117.40	98.05	2.85	216.4
Glens Falls	....	77.90	125.60	13.08	217.3
Cambridge	....	50	160	8.22	218.2
Schuylerville	....	27.55	182.65	8	218.2
Total	....	311.45	749	32.25	1,087.4
Final total	164.65	1,519.15	1,053.70	80.90	2,813.1

The following are the totals for the foregoing eight sheets: Virgin forest, 164.65 square miles; culled area, 1,207.70 square miles; cleared area, 304.70 square miles; water area, 48.65 square miles; total area, 1,725.7 square miles.

We also have five sheets either in or in the vicinity of Hudson River catchment area, namely, Fort Ann, North Creek, Glens Falls, Cambridge, and Schuylerville. The totals for these five sheets are, Virgin forest, 0; culled area, 311.45 square miles; cleared area, 749 square miles; water area, 32.25 square miles; total area of the five sheets, 1,087.4 square miles. In a portion of the region covered by these sheets the tendency is for many of the hard, stony hill farms to revert to forest conditions. We may assume, therefore, that throughout Adirondack region the forest area is slowly increasing.

As a summation of this discussion it may be concluded, taking into account the erection by the State of New York of Adirondack Park, as well as the tendency to abandon stony farms, that, on the whole, the conditions governing run-off of streams on upper Black River are slowly improving. Deductions, therefore, based on what has happened in the past, may be expected to be realized in the future.

THE ECONOMIC VALUE OF THE CITY OF WATERTOWN TO THE STATE OF NEW YORK.

In the State of New York there are seven large towns, at all of which the original basis of the development was water power, namely, Lockport, Rochester, Oswego, Watertown, Little Falls, Glens Falls, and Cohoes. The recent development of the city of Niagara Falls is also due purely to the water power of Niagara River, but this was not the original basis of growth. The attraction of the falls as a great natural curiosity gave this place its original impulse. There are also a number of smaller places in the State where water power has developed towns, but the foregoing are the larger ones. Moreover, so strong has been the impulse of the water power that several of these towns have developed at locations where there were serious adverse conditions. Thus at Lockport there is no water supply within reasonable distance. Even in 1899, aside from the original wells of the town, the water supply is still taken from Erie Canal, which receives the sewage of over 60,000 people at Buffalo. Lockport is an especially interesting case, because the original water power at that place was artificially created by the construction of Erie Canal.[1]

At Rochester the conditions were also somewhat forbidding. An extensive black-ash swamp occupied the area now covered by the original first, second, and third wards of that city and which is now largely the business part of the town.

Because of its location on Lake Ontario, and at the mouth of Oswego River, Oswego may be possibly considered a natural town site, although considerable amounts have been expended to construct a harbor there, while not very far away the fine harbors of Sodus bays are still practically unutilized. By way of comparing the Sodus bays harbors with Oswego, we may refer to the Annual Report of the Chief of Engineers for the fiscal year ending June 30, 1898, from which it appears that the total amount expended for harbor at Great Sodus Bay from May 23, 1828, to June 3, 1896, inclusive, is $475,646.80; at Little Sodus Bay from August 20, 1852, to June 3, 1896, total amount expended is $332,941.77; and at Oswego from March 20, 1826, to June 3, 1896, the total amount expended is $1,902,612.87. Had it not been for the water power at Oswego it is quite possible that the chief town of the east end of Lake Ontario might have been located at some place other than the mouth of the Oswego River, although in considering these figures as to cost of harbor we may properly take into account that Oswego has become a large town, while there are still only very small towns on Sodus bays.

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[1] For brief account of development of water power at Lockport see Water Supply and Irrigation Paper, No. 25, of the United States Geological Survey—Water Resources of State of New York, Part II, pp. 79-82. By George W. Rafter.

At Watertown the conditions for building a city may be considered fairly favorable, and the advantage of Black River water power has been accentuated by the admirable site.

At Little Falls rocky ledges of a narrow river gorge have operated to make the cost of building a town expensive, and the location of the water power at that point has been the governing condition.

Cohoes would not be selected as the site of a city aside from the location of extensive water power there.

Glens Falls may be considered a good site, and small towns like the neighboring villages of Fort Edward and Sandy Hill would probably in any event have grown up at this point.

Generally we may say that had it not been for the water power these seven chief manufacturing towns of New York would either never have come into existence, or at any rate would not have developed to any such extent as we now find them. In taking this view, however, it is not overlooked that with the towns once started other causes have contributed in some cases very materially to their advancement. What may be fairly assumed is that the water power was not only the determining cause for the location of all these towns, but that they have grown much larger on account of possessing the water power than they would otherwise have grown. It is also assumed that some of the locations are so unsatisfactory as to have prevented the growth of any town except there were some strong, predetermining cause like the possession of water power. It appears proper therefore to examine, in the present connection, as to the economic value of the water powers of Black River Valley to the State of New York.

TABLE NO. 127.—*Economic statistics of the city of Watertown, N. Y.*

Year.	Area.	Assessed valuation.	Rate on the dollar.	State tax.			Total State tax on an equal area of farming in the adjoining township of Watertown.	Annual net profit to the State on account of the city of Watertown. (7)−(8)	Present value of the annual net profit, being total increase in wealth in the State by reason of the values created at Watertown.
				For schools.	Exclusive of school tax.	Total. Sum of (5) and (6)			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Acres.								
1869	3,237	$3,171,702	$0.0059	$4,123.98	$14,433.88	$18,557.86	$449.14	$18,108.72	$130,937.73
1870	3,237	3,143,391	.0073	3,911.01	19,059.16	22,970.17	555.14	22,415.03	124,289.74
1871	3,237	3,315,210	.0054	3,992.10	14,078.82	18,070.92	404.78	17,666.14	90,303.96
1872	3,237	3,426,873	.0090	4,130.52	26,848.37	30,978.89	680.23	30,298.66	146,110.94
1873	3,237	3,638,820	.0068	4,481.77	20,408.85	24,890.62	511.14	24,379.48	110,911.81
1874	3,237	4,285,012	.0063	4,727.17	22,437.45	27,164.62	553.60	26,611.02	114,211.29
1875	3,237	7,838,424	.0031	5,057.00	19,219.00	24,276.00	496.82	23,779.18	96,280.53
1876	3,237	7,857,258	.0017	4,974.12	8,784.42	13,758.54	308.88	13,449.66	51,374.43
1877	3,237	7,267,536	.0023	5,214.85	9,540.96	14,755.81	341.04	14,414.77	51,944.25
1878	3,237	4,490,122	.0027	4,553.68	7,779.57	12,333.25	296.62	12,036.63	40,919.36
1879	3,237	6,196,145	.0020	4,764.80	7,796.55	12,561.35	307.84	12,253.51	39,298.73
1880	3,237	5,737,927	.0025	4,431.39	9,800.24	14,231.63	370.52	13,861.11	41,938.24
1881	3,237	5,069,394	.0017	4,509.22	4,390.55	8,899.77	235.17	8,664.60	24,731.74
1882	3,237	5,612,152	.0017	4,396.55	5,395.76	9,792.31	260.69	9,531.62	25,668.51
1883	3,237	5,360,216	.0024	4,219.60	8,490.07	12,709.67	333.47	12,376.20	31,432.94
1884	3,237	5,338,683	.0019	4,108.08	5,918.74	10,026.82	253.68	9,773.14	23,421.92
1885	3,237	5,345,960	.0021	3,777.82	7,403.86	11,181.68	268.52	10,913.16	24,673.64
1886	3,237	5,300,001	.0022	4,490.84	7,029.15	11,519.99	283.67	11,236.32	23,936.29
1887	3,237	5,363,697	.0020	4,389.54	6,384.79	10,774.33	264.63	10,509.70	21,147.60
1888	3,237	5,483,851	.0018	4,085.09	6,617.82	10,702.91	258.24	10,444.67	19,827.12
1889	3,237	5,653,686	.0027	4,101.99	10,783.60	14,885.59	349.54	14,536.05	25,031.87
1890	3,237	5,744,195	.0018	4,540.29	5,682.84	10,223.13	235.10	9,988.03	16,884.67
1891	3,237	6,230,433	.0010	4,725.66	1,772.09	6,497.75	135.67	6,362.08	10,140.08
1892	3,237	7,329,440	.0015	5,569.14	5,457.56	11,026.70	193.64	10,833.06	16,288.92
1893	3,237	8,010,611	.0021	6,191.02	10,534.46	16,725.48	262.43	16,463.05	23,353.15
1894	3,237	8,201,452	.0017	6,078.89	8,240.96	14,319.85	216.34	14,103.51	18,873.68
1895	3,237	8,481,123	.0026	6,197.09	15,544.31	21,741.40	312.63	21,428.77	27,053.34
1896	3,237	8,816,620	.0023	6,816.57	13,448.81	20,265.38	279.30	19,986.08	23,803.75
1897	3,237	9,287,426	.0021	6,452.72	13,117.03	19,569.75	270.44	19,299.31	21,684.71
1898	3,237	9,359,612	.0017	6,605.50	10,306.49	16,911.99	229.50	16,682.49	17,083.44
Total				145,624.00	326,706.16	472,330.16	9,918.41	462,411.75	1,435,193.38

In order to make such showing we may consider the statistics of the city of Watertown, as given by Table No. 127, showing the amount raised for State tax since 1869, in which year Watertown became a city, to 1898, inclusive. In this table column (1) shows the years in sequence; column (2) the area which has remained fixed during the whole period at 3,237 acres; column (3) the assessed valuation each year; column (4) the rate on the dollar of the State tax; columns (5), (6), and (7) the State taxes for each year; column (8) the total State tax on an equal area of farming land in the adjoining township of Watertown; column (9) the annual net profit to the State on account of the city of Watertown, that is to say, the difference of columns (7) and (8); and column (10) the present value (amount) of the annual net profit, being the total increase in wealth in the State by reason of the values created at Watertown. The rate of 6 per cent has been used in computing column (10). Referring to the footings of Table No. 127, it appears that the total State tax from 1869 to 1898, inclusive, has been $472,330.16, and that the total State tax on an equal area in the adjoining township of Watertown has been, for the same period, $9,918.41. A comparison of these two columns shows forcibly the economic value to the State of municipal developments. The footing of column (9), which is the difference of columns (7) and (8), is $462,411.75. The total present value (amount) is $1,435,193.38. These figures, it will be remembered, represent merely State taxation; they do not represent the increment to the county, the municipality itself, or to the private wealth of citizens.

Inasmuch as Lockport is a town of about the same size as Watertown, it is of interest to compare the statistics of the two places. Lockport was made a city in 1865, and the statistics have been brought up to and including the year 1896. The assessed valuation in 1865 was $2,929,130, while the assessed valuation of Watertown in 1869 was $3,171,702. The assessed valuation of Lockport in 1896 was $6,785,100, and of Watertown in 1898, $9,359,612. The total State tax at Lockport from 1865 to 1896, inclusive, was $511,861.59; the total State tax on an equivalent area of farming land in the adjoining township of Lockport was $17,692.88; the total annual net profit to the State on account of the city of Lockport for the whole period from 1865 to 1896, inclusive, was $494,169.16, and the present value (amount) is found to be $1,584,765.17.

According to Table No. 128, Water power in use on Black River in 1898, it appears that the total water power now actually in use at Watertown, including the Remington Paper Company's mill, just below the city, is as follows:

	Net horsepower.
Remington Paper Company	2,496
Taggart's dam	1,221
Lower level of Beebee's Island	1,022
Upper level of Beebee's Island	2,356
Lower dam, Sewall's Island	2,639
Upper dam, Sewall's Island	2,992
Davidson Marble Company	172
Watertown Waterworks	1,625
Total	14,523

Without taking up the several Black River manufacturing towns in detail, we may still refer briefly to Carthage, where the net water power in use, as per Table No. 128, in 1899, is as follows:

	Net horsepower.
Jefferson Power Company	3,474
Dam No. 17	1,734
Mill Island dam	821
State dam, Carthage	1,088
Total	7,117

These two cases illustrate the broad economic proposition involved in material interference with Black River water power.

WATER POWER ON BLACK RIVER IN 1898.

Diversion of water from Black River at Carthage will affect users of water power from that point to the mouth of stream, including manufacturing establishments at Carthage, Great Bend, Felts Mills, Black River, Watertown, Brownville, and Dexter, and powers along the stream at intervening points. Water-power interests at Lyons Falls, on Black River, and at Beaver Falls, on Beaver River, will also be injured by backwater due to raising the level of the water surface in the proposed storage reservoir.

Table No. 128 shows the general facts as to water power actually in use at the places indicated at the time the canvass was made, during the months of September and October, 1898. Referring to the table, the dams are numbered consecutively, beginning with the lowest on Black River, at Dexter. The mills are numbered in the order of their location on the flumes or power canals, beginning with the one farthest below the dam. In cases where there are power takings at both ends of a dam those on the right bank of the stream are usually given first.

Below are given the names of the owners of properties for cases where the name of the owner differs from that of the mill itself or of the present occupant. The mills are referred to by their serial numbers:

(2) St. Lawrence Paper Mill, Dexter. Owned by D. B. Gotham, Brownville.

(12) Brownville Paper Company, North Side Mill, Brownville. Owned by the Siouski Paper Company.

(23) Excelsior Roller Mills, Watertown. A. H. Herrick & Son Co., owners and proprietors.

(29) Union Mills, Watertown. J. A. Graves & Co., owners and proprietors.

(32) Kamargo Mills, Watertown. Knowlton Brothers, owners and proprietors.

(35) Building and power used by Johnston, Joyce & Co. and by S. B. Bartlett, Watertown. Owned by Watertown Electric Light Company.

(38) Watertown Screen Plate Works. McCarll & Stress, proprietors. Building and power owned by Knowlton Brothers, Watertown.

(61) Building and power used by Dexter Chair and Novelty Company are owned by the Jefferson Paper Company, Black River.

(62) Building and power used by Black River Machine Shop are owned by the Jefferson Paper Company, Black River.

(76) Building and power of Spicer & Skinner's cigar-box factory are owned by J. V. Guyot, Carthage.

(79) Building and power of Carthage Tissue Paper Company box factory are owned by E. Waters, Carthage.

(80) Building and power of the Carthage Tissue Paper Company cutting and winding department are owned by the Julia A. Rugg estate, Carthage.

Column (5) of the table gives the ordinary working head on the wheels in feet. Power users generally stated that the head on their wheels varied from 1 to 3 feet, according to the height of the water on crest of dam and in tailrace. In all cases the average working head, as stated by the users, has been given in the tables.

QUANTITY OF WATER USED FOR POWER PURPOSES IN CUBIC FEET PER SECOND AND TOTAL POWER DEVELOPED.

Columns (6) and (7) give the amount of water used by the water wheels in cubic feet per second and the net or effective horsepower developed when running at the head and width of opening of the speed gates stated by the power user. The power and discharge are as per rating given by the manufacturer of the wheel where this could be obtained. In cases where wheels are operated at part gate they have been rated at the same proportion of power and discharge at full gate that the stated average gate opening bears to the full opening of the speed gate. Wheels that run at varying widths of gate opening are rated by the above method at the mean of the stated limits of gate opening. Most such cases are included in the following:

Wheels stated to run at—

From 2/3 to full gate are rated at 5/6
From 1/2 to full gate are rated at 3/4
From 3/4 to full gate are rated at 7/8
From 1/2 to 2/3 gate are rated at 7/12
From 3/4 to 7/8 gate are rated at 13/16

Of the tabled power and discharge at full gate and under the same working head.

This method of rating wheels that run at part gate probably gives the power and discharge somewhat too small, inasmuch as many wheels are found by test to yield about three-fourths of their full power and discharge when running with the speed gates shut down to one-half of the full width of opening. On the other hand, the manufacturer's ratings are for wheels properly set and in good condition when running at the speed of greatest efficiency and can not apply with nicety to wheels as found in practice, often old, worn, overloaded, or otherwise out of repair.

There are a total of 331 water wheels in use at the mills included in the table. Of these—

223 run at full gate.
108 run otherwise than at full gate.
4 run at over three-quarters gate but less than full gate.
38 run at over one-half gate but not over three-quarters gate.
22 run at over one-quarter gate but not over one-half gate.
4 run at one-quarter gate or less.
12 are closed altogether.
28 run at greatly varying widths of gate from fractional to full.

The percentage of the theoretical efficiency on which the rated power is based, as per the manufacturer's tables, is as follows for some of the water wheels in most common use:

Kind of wheel.	Name of manufacturer.	Tabled efficiency.
		Per cent.
Leffel Double	Robert Poole & Sons, Baltimore, Md	88.5
Wait's Champion "Bloomingdale" or "Carthage."	McCarthy & Doremus Manufacturing Co., Sandy Hill, N. Y.: also made from some patterns by Ryther & Pringle, Carthage, N. Y.	88.0
Little Giant	William Dolan & Co., Logansport, Ind	87.5
Victor Register Gate	Stillwell-Bierce & Smith-Vaile Co., Dayton, Ohio	85.0
Camden Vertical	Camden Water Wheel Works, Camden, N. Y	83.6
Leffel Standard	James Leffel & Co., Springfield, Ohio	83.5
Crocker	E. D. Jones & Sons, Pittsfield, Mass	83.3
Curtis Regular	Gates Curtis, Ogdensburg, N. Y	83.0
Risdon	T. H. Risdon & Co., Mount Holly, N. J	82.8
Hunt Standard	Rodney Hunt Machine Co., Orange, Mass	82.0
No. 1 and No. 2 Success	S. Morgan Smith, York, Pa	80.0
Hercules	Holyoke Machine Co., Holyoke, Mass	80.0
New American	Dayton Globe Iron Works, Dayton, Ohio	80.0
High Duty	T. C. Alcott & Son, Mount Holly, N. J	80.0
Victor Cylinder Gate	Stillwell-Bierce & Smith Vaile Co., Dayton, Ohio	79.7
Curtis Register Gate	Gates Curtis, Ogdensburg, N. Y	79.8
Trump Model	Trump Manufacturing Co., Springfield, Ohio	78.7

Auxiliary steam power is in use in thirteen establishments, as shown in column (8) of Table No. 128. The aggregate steam power in use is 1,482 horsepower and this is entirely confined to paper mills, where it is chiefly used to drive paper machines. There is very little steam power in reserve for use in emergency or low water.

ASSUMED VALUATION OF THE PROPERTIES.

Under the heading of valuation of property, as given in column (10) of the table, it is intended to include:

(1) The value of the water privilege, or right to use water for purposes of power.

(2) The site, land or grounds belonging to the mill property.

(3) The buildings, including dams, race ways, and other structures.

(4) Machinery, including water wheels.

In many cases it was necessary to explain to power users, in detail, just what was wanted. The valuations given do not in general include raw materials, stock on hand, capital not directly invested, nor the "value of the business" or "good will of the firm" as commonly understood.

In the following cases, where the valuations could not be obtained directly, the valuations have been estimated as given below:

Serial No.	Name of establishment.	Estimated valuation of property.
1	Dexter Sulphite Pulp and Paper Co., Dexter	$80,000
2	St. Lawrence Paper Mill, Dexter	24,000
26	New York Air Brake Co., Watertown (main plant)	225,000
35	Building owned by Watertown Electric Light Co	10,000
38	Watertown Screen Plate Works	8,000
39	New York Decorating and Veneering Co., Watertown	8,000
55	Watertown Waterworks Pumping Station	75,000
65	Jefferson Paper Co., Black River	100,000
68	Jefferson Power Co., Great Bend	150,000
70	M. P. Mason, Carthage	20,000
77	American Electric Light Co., Carthage	20,000
86	A. E. Maxwell Pulp Mill, Carthage	14,000

The following table shows the inventory valuation of the properties in cases where this has been given:

Serial No.	Name of establishment.	Real estate buildings and water rights.	Machinery.	Raw material and stock on hand.	Total valuation.
19	Union Carriage and Gear Co	$27,000	$44,084	$83,000	$154,084
23	Excelsior Flour Mills	27,000	17,000		44,000
28	Zimmerman & Hardiman				10,000
44	Watertown Spring Wagon Co	100,000	40,000		200,000
47	Excelsior Carriage Co.	40,000	10,000	50,000	100,000
85	Myer & Farrar, Carthage	12,000	6,000		18,000

The cost, complete, of the following plants was stated as below:

Serial No.	Name of establishment.	Stated cost, complete.	Remarks.
12	Brownville Paper Co	$87,000	Purchase price and improvements North Side Mill.
14	International Paper Co	400,000	Price said to have been paid by present owner.
31	George A. Lance	25,000	Original cost, complete.
61	Dexter Chair and Novelty Co	9,000	Price paid by present owner.
69	West End Pulp and Casket Co	250,000	Cost, including mill now being erected.
74	Carthage Waterworks	55,300	Pumping station and distributing system.
83	Carthage Sulphite Co	85,000 100,000	Cost of buildings and machinery. Total valuation, including real estate.

The following notes relate to the valuations of other water-power properties that may be referred to in the table by their serial numbers:

(11) C. E. Codman, Brownville. The assessor's valuation is given; in this case being $2,500.

(26) The New York Air Brake Company state the total valuation of their property at $5,000,000. This includes stock, patents, surplus capital, and value of the business. The author has estimated value of plant and machinery at $225,000, not including new foundry erected in 1898, costing $15,000, and which is included in serial No. 30 of the table.

(36) J. B. Wise, owner of building and power of the industrial plant, estimates value of his property in the plant at $120,000.

The industrial plant includes Foster & Begg, furniture factory; White & Sullivan, sash, doors, and blinds; Ryther Manufacturing Company, batting presses; J. B. Wise, light hardware.

(37) Watertown Electric Light Works:

Value of central station, including site, water power, machinery, and building, stated at	$90,000
Street equipment stated at	30,000
Total valuation stated at	120,000

(46) Bagley & Sewall Company:

Capital	$100,000
Capital surplus	185,000
Total valuation	285,000

This is stated to be practically all invested in machinery, buildings, and the real estate of the plant.

(55) Watertown Waterworks pumping station. Site with water power undeveloped cost $2,000, including 20 acres of land. Baker's Manual of American Waterworks states original cost of entire system, including dams, pumping station, and distributing system, to have been $383,000. New centrifugal pumps have since been put in. The author has estimated value of station alone, with developed water power, at $75,000, including land, as stated in the foregoing.[1]

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[1] The total power of this pumping station is stated at 1,625 horsepower. Probably not more than 300 to 400 horsepower is ordinarily used.

TABLE NO. 128.—*Water power in use on Black and Beaver rivers in 1898 (approximate).*

No. of dam from mouth of stream.	No. of mill.	Owner or operator of mill.	Nature of business.	Ordinary working head, in feet.	Water used, in cubic feet per second.	Horsepower of water wheels at stated head and gate opening.	Gross power of water used as per columns (5) and (6) at theoretical efficiency.	Net power of water used as per columns (5) and (6), efficiency of water wheels 75 per cent.	Horsepower of engines in daily use.	Total power ordinarily in use.	Assumed valuation of property.	Valuation per horsepower of total power in use as per column (9).	Value of the annual product.	Value of the annual product per each horsepower of total power in use.	Ratio of valuation of property to value of annual product.	Total number of hands employed.	Total horsepower in use for each hand employed.	Remarks.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(7a)	(7b)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
*a*1	1	Dexter Sulphite Pulp and Paper Co.	Bisulphite fiber	15	430	585	732	549	125	710	$80,000	$113	$153,000	$201	1.9	200	3.6	Column (14) = column (12) ÷ column (10).
1	2	St. Lawrence Paper Mill.	Wood pulp and paper.	12	533	588	726	544	75	663	24,000	36	100,000	151	4.1	40	6.6	
1	3	Binninger & Strange.	Sash, doors, and blinds.	9	129	108	132	99	None.	108	10,000	92.5	......	......	......	27	4	
1	4	Leonard & Gilmore.	Pulp and planing mill.	14	228	278	362	272	None.	278	20,000	72	13,430	48	0.67	11	25.2	
1	5	N. R. Cooke, estate.	Feed and flour mill.	10	28	15	32	24	None.	15	10,000	665	......	......	......	1	15	
1	6	Jones & Hunter.	Gristmill	9	40	25	41	31	None.	25	3,000	120	1,050	42	0.35	2	12.5	
1	7	.....do	Pulp and sawmill	13	462	545	682	511	None.	545	17,000	31	13,000	34	0.76	6	90	
1	8	Frontenac Paper Co.	Wood pulp and paper.	13	452	533	668	501	80	613	400,000	63	112,000	184	1.12	40	15.3	
		Total at Dexter		......	2,303	2,677	3,375	2,582	280	2,957	564,000	......	392,480	......	......	327	......	
2	9	Outterson Paper Co.	Wood pulp and paper.	16	560	833	1,017	763	None.	833	90,000	107.6	150,000	180	1.67	45	18.4	Dam No. 2 is at Brownville.
2	10	Brownville Iron Works.	Paper mill machinery.	13½	43	45	66	49	None.	45	60,000	133.4	150,000	333	2.50	27	1.7	
2	11	C. E. Codman	Planing and feed mill.	12½	39	45	50	37	None.	45	2,500	55.5	......	......	......	2	22.5	
2	12	Brownville Paper Co.	North side pulp and paper mill.	16	572	840	1,039	779	None.	890	85,000	95.5	100,000	119	1.17	27	33	
2	13	.....do	South side pulp and paper mill.	16	651	957	1,182	887	None.	957	67,000	67.5	110,000	115	1.64	30	32	
		Total at Brownville		......	1,865	2,720	3,354	2,515	None.	2,720	304,500	......	510,000	......	......	131	......	

8	14	International Paper Co.	Wood pulp and paper.	31	1,244	3,708	4,377	3,282	None.	3,708	400,000	108	378,700	102	0.95	70	53	Located above Brownville.
4	15	C. R. Remington & Son Co.	.... do	32½	1,582	4,692	5,836	4,377	200	4,952	225,000	45	373,700	75.5	1.06	75	66	At Glen Park, above Brownville.
5	16	Remington Paper Co.	Wood pulp	16	1,724	2,496	3,130	2,348	None.	2,496	200,000	80	116,000	46.5	0.58	23	108	Below Watertown.
b 6	17	Taggart Bros. Co.	Wood pulp, paper and paper bags.	9,11	697	695	800	645	None.	695	100,000	144	175,000	252	1.75	54	13	
6	18	... do.	Electric power house.	12	329	364	448	336	None.	364	....	....	....	......	......	None.	......	
6	19	Union Carriage and Gear Co.	Spring wagons, carriages, sleighs.	14	51	41	81	61	None.	41	71,000	174	120,000	292	1.70	78	0.53	
6	20	Watertown Brass and Manufacturing Co.	Discontinued business, idle.	14	None.	None.	None.	None.	None.	None.	16,000	....	None.	......	......	None.	......	
6	21	Watertown Thermometer Co.	Thermometers .	10	81	37	92	60	None.	37	18,000	486	50,000	135	2.77	50	0.74	
6	22	Elwood Silk Co.	Broadsilks, organzine, etc.	13	69	84	102	76	None.	84	80,000	952	150,000	178	1.88	125	0.67	
6		Total at Taggart's dam, Watertown.		......	1,227	1,221	1,583	1187	......	1,221	285,000	....	495,000	......	......	307	......	
c 7	23	Excelsior Flour Mill.	Custom milling..	10,11	231	171	268	201	None.	171	15,000	87	....	......	......	14	12.2	
7	24	Roblin & Hotchkin.	Sash and blinds .	10	38	36	43	32.4	None.	36	8,000	222	37,500	104	4.60	10	3.6	
7	25	Case & Foulsom .	.... do	18	9	10	18	14	None.	10	17,000	1,700	....	......	......	8	1.25	
7	26	New York Air Brake Co.	Air brakes......	10,11,18	548	684	798	598	None.	684	225,000	329	1,500,000	2,193	6.67	650	1.05	
7	27	Sloat & Greenleaf.	Sash and blinds.	12	112	121	152	114	None.	121	25,000	140	....	......	......	13	9.3	
7	28	Zimmerman & Hardiman.	Furniture..... ...	15	None.	None.	None.	None.	None.	None.	10,000	......	None.	......	......	None.	...	
7		Total at lower level, Beebe's Island, Watertown.		......	938	1,022	1,279	959.4	None.	1,022	300,000	.....	1,537,500	....	....	695	....	
7	29	Union Mills......	Grist mill.......	12	131	145	1.78	134	None.	145	40,000	276	180,000	1,241	4.5	11	13.2	
7	30	New York Air Brake Co.	Foundry	9	105	86	108	81	None.	86	15,000	......	....	......	......	......	......	
7	31	Geo. A. Lance ..	Foundry and machine shop.	10	42	21	48	36	None.	21	10,000	476	35,000	1,667	3.5	20	1	

a Dam No. 1 at Dexter is in two sections, joining the opposite sides of an island with the mainland.
b Dam No. 6 is the lowest on the stream within the city of Watertown
c Dam No. 7 at Mill street, Watertown, joins the opposite sides of Beebe's Island with the mainland. Water is used at two levels. The tail water of the upper-level flumes discharge into the head races of the lower level.

TABLE No. 128.—*Water power in use on Black and Beaver rivers in 1898 (approximate)*—Continued.

No. of dam from mouth of stream. (1)	No. of mill. (2)	Owner or operator of mill. (3)	Nature of business. (4)	Ordinary working head, in feet. (5)	Water used, in cubic feet per second. (6)	Horsepower of water wheels at stated head and gate opening. (7)	Gross power of water used as per columns (5) and (6) at theoretical efficiency. (7a)	Net power of water used as per columns (5) and (6), efficiency of water wheels 75 per cent. (7b)	Horsepower of engines in daily use. (8)	Total power ordinarily in use. (9)	Assumed valuation of property. (10)	Valuation per horsepower of total power in use as per column (9). (11)	Value of the annual product. (12)	Value of the annual product per each horsepower of total power in use. (13)	Ratio of valuation of property to value of annual product. (14)	Total number of hands employed. (15)	Total horsepower in use for each hand employed. (16)	Remarks. (17)
7	32	Kamargo Mills	Wood pulp and paper.	14, 18	826	1,280	1,584	1,188	None.	1,280	$175,000	$137	$175,000	$137	1.0	50	25.6	
7	33	Harmon Machine Co.	Paper mill machinery.	12	71	80	97	73	None.	80	75,000	937	75,000	937	1.0	30	2.7	
7	34	Hitchcock Lamp Co.	Lamps, etc	8, 10	296	250	311	233	None.	250	60,000	769	140,000	1,795	2.33	115	0.68	
7	35	Johnson, Joyce & Co.	Spring beds	13	16	10	24	18	None.	10	10,000	1,000	3,000	300	0.33	7	1.4	
7	36	J. B. Wise Industrial Plant.	General manufacture.	20	98	168	222	166	None.	168	120,000	714	......	......	......	78	2.15	
7	37	Watertown Electric Light Co.	Municipal lighting, etc.	25	190	458	539	404	None.	458	120,000	262	......	......	......	13	35	
7	38	Watertown Screen Plate Works.	Screen plates	16	21	30	38	29	None.	30	8,000	266	6,500	216	0.81	4	7.5	
7	....	Total at upper level, Beebe's Island, Watertown.		......	1,796	2,528	3,149	2,362	None.	2,528	633,000	......	614,500	......	......	328	......	
7	....	Total for both levels at Beebe's Island.		......	2,734	3,550	4,428	3,321.4	None.	3,550	933,000	......	2,152,000	......	......	1,023	......	
*a*8	39	New York Decorating and Veneer Co.	Veneer manufacturing.	16	45	66	81.7	61.3	None.	66	8,000	121	......	......	......	12	5.5	
8	40	Charlebois Bros	Sash and blinds	16	28	40	50.8	38.1	None.	40	7,000	175	......	......	......	6	6.67	
8	41	Nelson Burdick	Plant not occupied.	15	None.	None.	None.	None.	None	None.	6,000	......	None.	......	......	None.	......	
8	42	Nill & Jess Co	Bakery	14	98	123	156	117	None.	123	60,000	488	110,000	893	1.83	37	3.3	
8	43	H. H. Babcock Co	Carriages	16, 18	985	1,634	1,976	1,482	None.	1,634	300,000	183	1,500,000	918	5.0	350	4.66	

8	44	**Watertown Spring and Wagon Co.**	Spring wagons and buggies.	11	138	146	172	129	None.	146	200,000	137	300,000	205	1.5	200	0.73	
8	45	**Farwell & Rhines**	Flour and feed	12, 16	360	500	607	455.3	None.	500	100,000	200	400,000	800	4.0	16	31.2	
8	46	**Bagler & Sewell Co.**	Paper-mill machinery.	12, 16	104	130	162	121.5	None.	130	100,000	770	300,000	2,310	3.0	200	0.65	
8	....	Total at lower dams, Sewall's Island, Watertown.		....	1,758	2,639	3,205.5	2,404.2	None.	2,639	781,000	....	2,610,000	......	....	821	......	
*b*9	47	Excelsior Carriage Co.	Carriages	12	48	55	65	48	None.	55	50,000	900	175,000	318	3.5	75	0.73	
9	48	Remington Paper Co. (Mill A).	Paper	17	176	282	340	255	100	382	225,000	589	387,500	114	1.72	74	5.16	
9	49	Remington Paper Co. (Mill B).	.... do	17	113	170	218	164	85	255	160,000	627	248,000	941	1.5	74	3.44	
9	50	Remington Paper Co. (Mill C).	Wood pulp	14	725	916	1,152	864	None.	816	50,000	61	37,440	45.8	0.75	10	81.06	
9	51	Remington Paper Co. (Mill D).	....do	13	746	980	1,100	825	None.	980	45,000	46	31,200	31.8	0.69	9	10.89	
9	52	Remington Paper Co. (Sulphite mill).	Sulphite fiber ...	10, 15, 16	190	240	293	220	None.	240	220,000	917	210,800	87.8	0.96	56	4.28	
9	53	Watertown Paper Co.	Paper	11	168	172	210	157	92	264	30,000	113.7	180,000	681.4	6.0	50	5.28	
9	....	Total at upper dams, Sewall's Island, Watertown.		....	2,166	2,815	3,378	2,533	277	3,092	780,000	....	1,269,940	....	....	348	....	
8, 9	....	Total for dams at Sewall's Island, Watertown.		....	3,924	5,454	6,583	4,937	277	5,731	1,561,000	......	3,879,940	....	....	1,169	....	
10	54	Davidson Marble Co.	Marble works ...	9¼	198	172	214	160.5	None.	172	75,000	43.6	72,000	418.6	0.96	35	4.86	½ mile east of Watertown.
11	52	Watertown Waterworks.	Pumping station.	20	893	1,625	2,027	1,520	None.	1,625	75,000	....	....	....	....	2	812.5	1 mile east of Watertown.
12	56	Watertown Paper Co.	Wood pulp	18, 20	753	1,324	1,626	1,219.5	None.	1,324	150,000	113.3	81,000	61.1	0.51	18	73.55	Below Black River.
13	57	Thomas Childs & Son.	Sash and blinds	......	None.	None.	None.	None.	None.	None.	6,000	......	None.	......	......	......	......	
*c*13	58	Black River Bending Co.	Furniture	15	313	427	533	400	None.	427	30,000	70.2	25,000	58.5	0.84	30	14.23	
13	59	Black River Wood Pulp Co.	Wood pulp.......	14	242	315	384	288	None.	315	25,000	79.3	31,500	106	1.28	6	52.26	
13	60	H. C. Dexter Chair Co.	Chairs	15	98	133	167	125	None	133	25,000	188	60,000	451.1	2.4	60	2.22	

a Dam No. 8 is in two sections, joining the opposite sides of the lower end of Sewall's Island with the mainland.

b Dam No. 9 is in two sections, joining the opposite sides of the upper end of Sewall's Island with the mainland.

c Dam No. 13, at Black River, consists of a main timber section joining Jefferson Island with the mainland and two smaller sections joining Jefferson and Mill islands and Mill Island with the mainland, respectively.

TABLE NO. 128.—*Water power in use on Black and Beaver rivers in 1898 (approximate)*—Continued.

No. of dam from mouth of stream.	No. of mill.	Owner or operator of mill.	Nature of business.	Ordinary working head, in feet.	Water used, in cubic feet per second.	Horsepower of water wheels at stated head and gate opening.	Gross power of water used as per columns (5) and (6) at theoretical efficiency.	Net power of water used as per columns (5) and (6), efficiency of water wheels 75 per cent.	Horsepower of engines in daily use.	Total power ordinarily in use.	Assumed valuation of property.	Valuation per horsepower of total power in use as per column (9).	Value of the annual product.	Value of the annual product per each horsepower of total power in use.	Ratio of valuation of property to value of annual product.	Total number of hands employed.	Total horsepower in use for each hand employed.	Remarks.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(7a)	(7b)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
13	61	Dexter Chair and Novelty Co.	Chairs	10,11	104	112	111	83	None.	168	$8,100	$48.2	$37,500	$223	4.63	20	8.4	
13	62	Black River Machine Shop.	Repairing, etc.	8	.....	.....	.....	.....	.....	.....	900	.....	.....	.....	.....	2	.....	
13	63	W. S. Wilcox & Son.	Furniture	13	20	15	30	22	None.	15	4,000	266.7	.....	.....	.....	1	15	
13	64	Empire Wood Pulp Co.	Wood pulp, grist mill.	14	451	601	716	537	None.	601	29,000	48.2	20,250	33.7	0.69	8	75.12	
13	65	Jefferson Paper Co.	Wood pulp and paper.	14	1,408	1,820	2,237	1,678	80	1,900	100,000	52.6	247,500	130	2.47	60	3,167	
13	....	Total at Black River		.....	2,636	3,423	4,178	3,133	80	3,503	228,000	.....	421,750	.....	.....	187	.....	
14	66	Taggart Paper Co.	Printing paper	12,13	1,583	1,907	2,330	1,747.5	175	2,082	500,000	240	300,000	144.9	0.6	75	27.76	Felt's Mills.
15	67	....do	Wood pulp and paper.	18	91.	1,497	1,873	1,405	None.	1,497	100,000	66.8	100,000	66.8	1	40	37.42	Great Bend.
16	68	Jefferson Power Co.	....do	21	1,69	3,324	4,042	3,031	150	3,474	150,000	43.2	193,500	55.4	1.29	45	77.2	Between Great Bend and Carthage.
a17	69	West End Pulp and Casket Co.	Wood pulp and caskets	18	945	1,676	1,930	1,448	None.	1,676	250,000	149	45,000	26.9	0.18	15	111.6	
17	70	M. P. Mason	Map rollers, etc.	9	64	55	65	49	None.	58	20,000	344.8	22,500	387.9	1.13	25	2.3	
17	....	Total at Dam No. 17, Carthage		.....	1,009	1,734	1,995	1,497	.....	1,734	270,000	.....	67,500	.....	.....	40	.....	

b 18	71	Maxwell & Younsel.	Wood-pulp cardboard.	13	522	617	770	578	80	697	90,000	129.1	72,000	103.3	0.8	22	31.7
18	72	Adirondack Machine Co.	Wood-pulp machinery.	11	38	38	47	35	None.	38	52,000	1,369.4	55,000	1,447.3	1.1	40	0.95
18	73	Balcom & Spicer.	Hard-wood veneers.	12	78	86	106	79	None.	86	8,000	93	......	......	......	7	12.30
18	....	Total at Mill Island Dam, Carthage.		......	638	741	923	692	80	821	150,000	......	127,000	......	......	69	......
c 19	74	Carthage Waterworks.	Pumping station	7¼	87	63	74	55	None.	63	55,000	873	......	......	......	1	63
19	75	Frank Guyot....	Planing mill. ..	7¼	6	4	5	4	None.	4	5,400	1,350	......	......	......	1	4
19	76	Spicer & Skinner	Cigar-box factory.	6¾	2	1	1.4	1	None.	1	700	700	......	......	......	2	0.5
19	77	American Electric Light Co.	Municipal lighting.	8½	245	192	236	177	None.	192	20,000	104.1	......	......	......	3	64
19	78	J. V. Guyot	Grist mill........	8	47	39	43	32	None.	39	4,000	......	......	......	......	2	19.5
19	79	Carthage Tissue Paper Co.	Paper boxes	9½	34	34	37	28	None.	34	6,000	176.5	4,500	132.3	0.85	4	8.5
19	80	.....do	Tissue papers ...	9½	229	209	247	185	None	209	100,000	483	137,500	619.3	1.33	40	55.5
19	A80	.....do	Toilet papers....	8	16	13	14	11	None.	13	3,500	269.2					
19	81	Julia A. Rugg estate.	Grist mill........	8	20	15	18	14	None.	15	3,000	200	......	......	......	2	7.6
19	82	Ryther & Pringle.	Machine shop....	8	41	33	37	28	None	33	39,000	1,181.8	30,000	909	0.77	20	1.65
19	85	Carthage Sulphite Paper Co.	Sulphite fiber ..	17	108	168	208	156	None.	168	150,000	395.2	150,000	892.8	1.5	35	4.8
19	84	Carthage Roller Mills.	Grist mill........	9	75	69	76	57	None.	69	15,000	217.4	80,000	1,159.4	5.3	2	34.5
19	85	Myer & Farrar .	Sash and blinds .	8, 9	30	26	28	21	None.	26	18,000	692.3	25,000	961.5	1.4	25	1
19	86	A. E. Maxwell....	Pulp mill	8	281	222	255	191	None.	222	18,000	85.6	13,500	60.8	0.75	5	44.5
19	....	Total at State Dam, Carthage.		......	1,221	1,088	1,279.4	960	None.	1,038	387,600	......	440,500	......	......	142	......
20	87	H. C. Markham *d*	Grist mill........	22	60	75	150	112	None.	75	5,000	66.7	......	......	......	4	19
20	88	.... do	Electric-light plant.	22	None.	None.	None.	None.	None.	None.		......	......	......	......	None.	......
20	89	Gould Paper Co	News paper......	67	1,266	7,731	9,628	7,221	None.	7,731	650,000	84.1	337,500	41.6	0.5	76	101.7
20	....	Total at Lyons Falls.		......	1,326	7,806	9,778	7,333	None.	7,806	655,000	......	337,500	......	......	80	......
1	1	J. P. Lewis Pulp and Paper Co.	Wood pulp, etc ..	16	426	653	774	580	130	783	225,000	135.5	220,000	280.9	1.53	......	......
2	2	J. P. Lewis Co. *e*	..... do	18	527	885	1,076	807	None.	885		......	39,500	44.6		6	147.5

a Lowest dam on the stream at Carthage.
b These mills are located on an island joined to the mainland by the sections of Dam No. 18, Carthage.
c Dam No. 19 at Carthage, N. Y., is known as the State dam. Mills on the river bank are chiefly located on Guyot's and Furnace islands.
d Markham's mill takes water from Black River Canal at Lyons Falls.
e On the Beaver River at Beaver Falls.

TABLE NO. 128.—*Water power in use on Black and Beaver rivers in 1898 (approximate)*—Concluded.

No. of dam from mouth of stream.	No. of mill.	Owner or operator of mill.	Nature of business.	Ordinary working head, in feet.	Water used, in cubic feet per second.	Horsepower of water wheels at stated head and gate opening.	Gross power of water used as per columns (5) and (6), at theoretical efficiency.	Net power of water used as per columns (5) and (6), efficiency of water wheels 75 per cent.	Horsepower of engines in daily use.	Total power ordinarily in use.	Assumed valuation of property.	Valuation per horsepower of total power in use as per column (9).	Value of the annual product.	Value of the annual product per each horsepower of total power in use.	Ratio of valuation of property to value of annual product.	Total number of hands employed.	Total horsepower in use for each hand employed.	Remarks.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(7a)	(7b)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
2	3	Lewis & Slocum	Wood-pulp board	11	56	59	70	53	50	109	$125,000	$1,146.8	$86,800	$796.3	0.69	20	5.4	
4	4	Lewis, Slocum & Lefebvre.	Wood pulp	30	454	1,294	1,546	1,159	None.	1,294	75,000	58	102,300	79	1.36	16	80	
		Total on Beaver River at Beaver Falls.		......	1,463	2,891	3,466	2,599	180	3,071	425,000	....	448,600	....	......	42	....	
		Total both streams		......	......	54,050	66,398	49,797	1,482	55,552	7,638,100	....	10,887,170	....	......	3,900	....	

(89) Gould Paper Company, Lyons Falls. The company's asking price for this property is $650,000.

VALUE OF THE ANNUAL PRODUCT.

The value of the annual product, as given in column (12) of the table, is in general as stated by the proprietor of each establishment. In the case of pulp and paper mills where the pulp made is consumed in the manufacture of paper in the same mill, the real value of the annual product represents only the selling value of the finished paper. In cases where companies own separate pulp and paper mills, the product of the former being used in the latter, the value of the pulp alone has been taken as the value of the annual product of the pulp mills. This has been done to make the figures given for such cases comparable with those for other mills where the pulp is sold directly as a finished product and for paper mills that purchase their pulp. In cases where the value of the annual product fluctuates largely the average has been taken. In the following notes relative to the value of the annual product in certain establishments the mill referred to in each case is designated by its serial number, as in the table. In some cases the value of the annual product of pulp and paper mills has been estimated from the amount of the daily product at the average price stated by the manufacturers and for a working year of three hundred days, unless otherwise stated by the manufacturer.

(3) A large part of the work of Binninger & Strange consists of the construction of buildings, and the actual value of the annual product resulting from the use of water power can not be stated.

(4) The total receipts for pulp by the Leonard & Gilmore Company in the year 1891 were $13,430. This has been taken as the total value of the annual product, inasmuch as the manufacture of sash, doors, and blinds by this firm is very irregular and consumes comparatively little power.

(11) Value of the annual product of Codman's feed and planing mill varies greatly, and was not known by the proprietor.

(18) Taggart Brothers' power house furnishes power to Black River Traction Company, but the rental rate for power was not stated. The valuation of the plant is included in that of the Taggart Paper Company's mill, of which it forms a part.

(20) The Watertown Brass Manufacturing Company has discontinued business, and the plant is now idle.

(28) The furniture factory of Zimmerman & Hardiman was closed for repairs at the time the canvass was made. It was stated that the plant would be in operation after about October 1, 1898.

(40) The work done by Charlebois Brothers is largely on building contracts taken by the firm, and the separate annual value of the shop work could not be given.

(41) Building and water power owned by Nelson Burdick, but not now occupied.

(55) Watertown waterworks. Rental rates for water are:

	Per year.
For family use	$4
For water-closet	2
For bath	1
For horse and carriage	1
For lawn hose	3

The total annual receipts from water rentals were not stated.

(57) Thomas Childs & Son take their power from the water wheels of the H. C. Dexter Chair Company by a teledynamic transmission. Their plant was idle at the time the canvass was made.

(62) The Black River Machine Shop does repair work only. The amount of the yearly earnings was not known.

(75), (76), and (78) These mills run irregularly a part of the time; value of the annual product not known.

(77) American Electric Light Company has a contract, dated 1898, to light the town of Carthage for five years. The annual receipts for municipal and commercial lighting were not stated.

RELATION BETWEEN THE TOTAL POWER IN USE, VALUATION OF THE PROPERTY, VALUE OF THE ANNUAL PRODUCT, AND NUMBER OF HANDS EMPLOYED.

Column (14) of Table No. 128 gives the ratio obtained by dividing the value of the annual product, as per column (12), by the estimated valuation of the property, as per column (10). This ratio represents the number of times per year that the value of the total permanent investment is turned over in actual business done.

Column (15) gives the total number of hands employed. In cases where the number of employees varies, the number of hands employed, as given in the table, represents the average number permanently employed.

Table 128 A shows the relative extent and importance of the different classes of manufacture.

PLATE C.

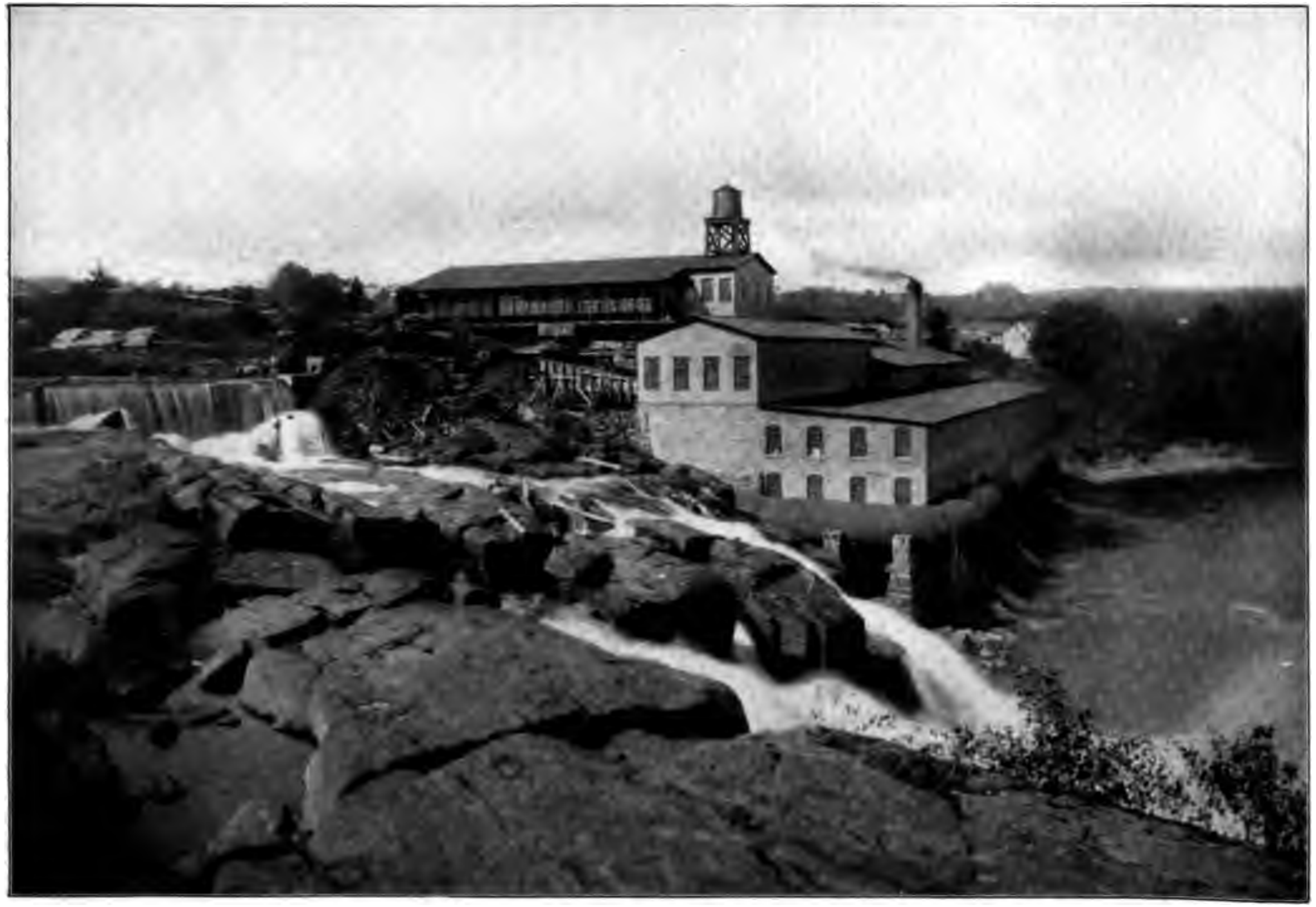


Photo by R. E. H.

WATER-POWER DEVELOPMENT AT LYONS FALLS IN 1898.

PLATE D.

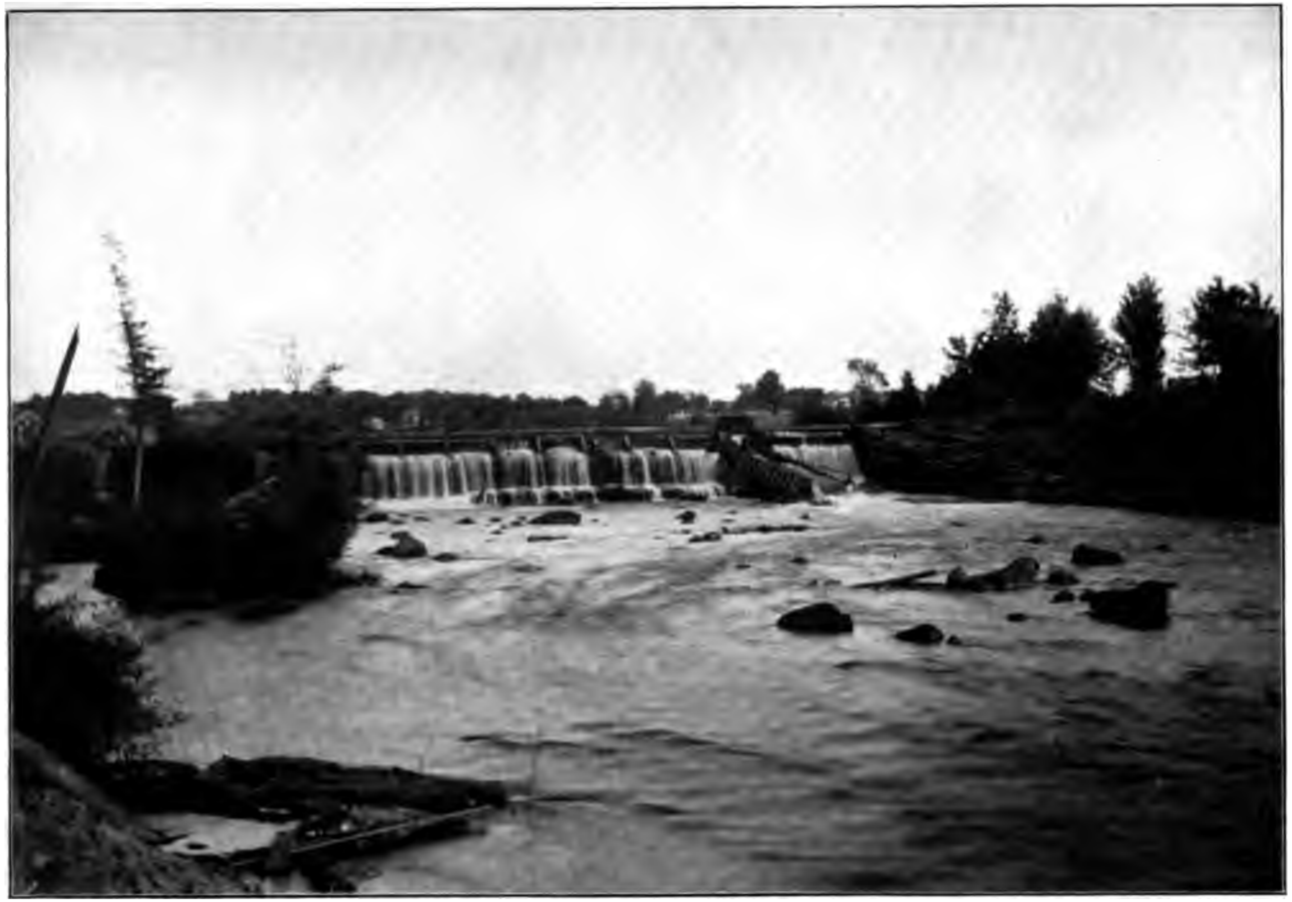


Photo by R. E. H.

THE J. P. LEWIS DAM AT BEAVER FALLS. TO BE FLOODED BY BLACK RIVER RESERVOIR.

PLATE E.

Photo by R. E. H.

LOOKING DOWN BEAVER RIVER FROM ABOVE THE HIGHEST DAM AT BEAVER FALLS

PLATE F.

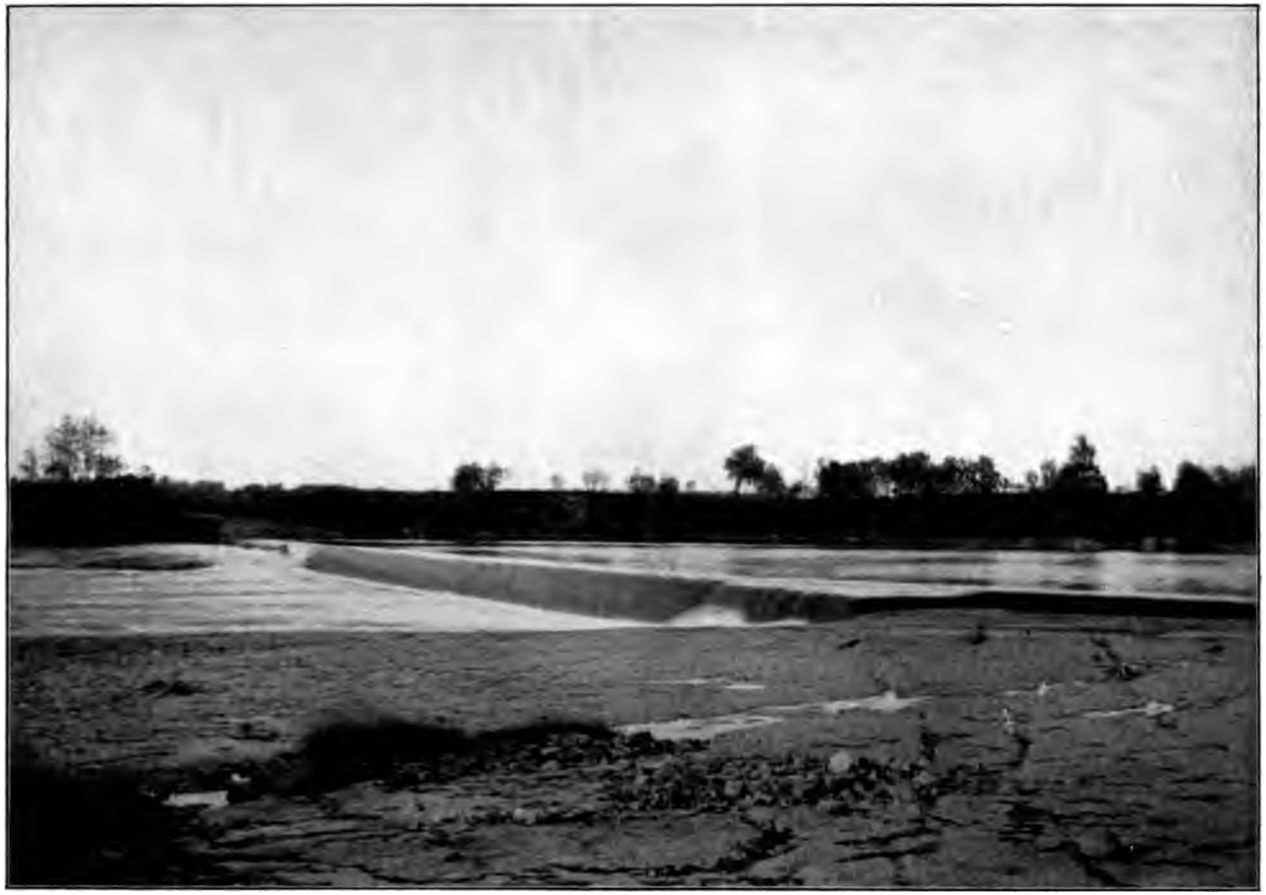


Photo by R. E. H.

THE HUNTINGTONVILLE DAM ON BLACK RIVER AT WATERTOWN

PLATE G.

Photo by R. E. H.

DAM OF WEST END PULP AND CASKET COMPANY AT CARTHAGE.

PLATE H.

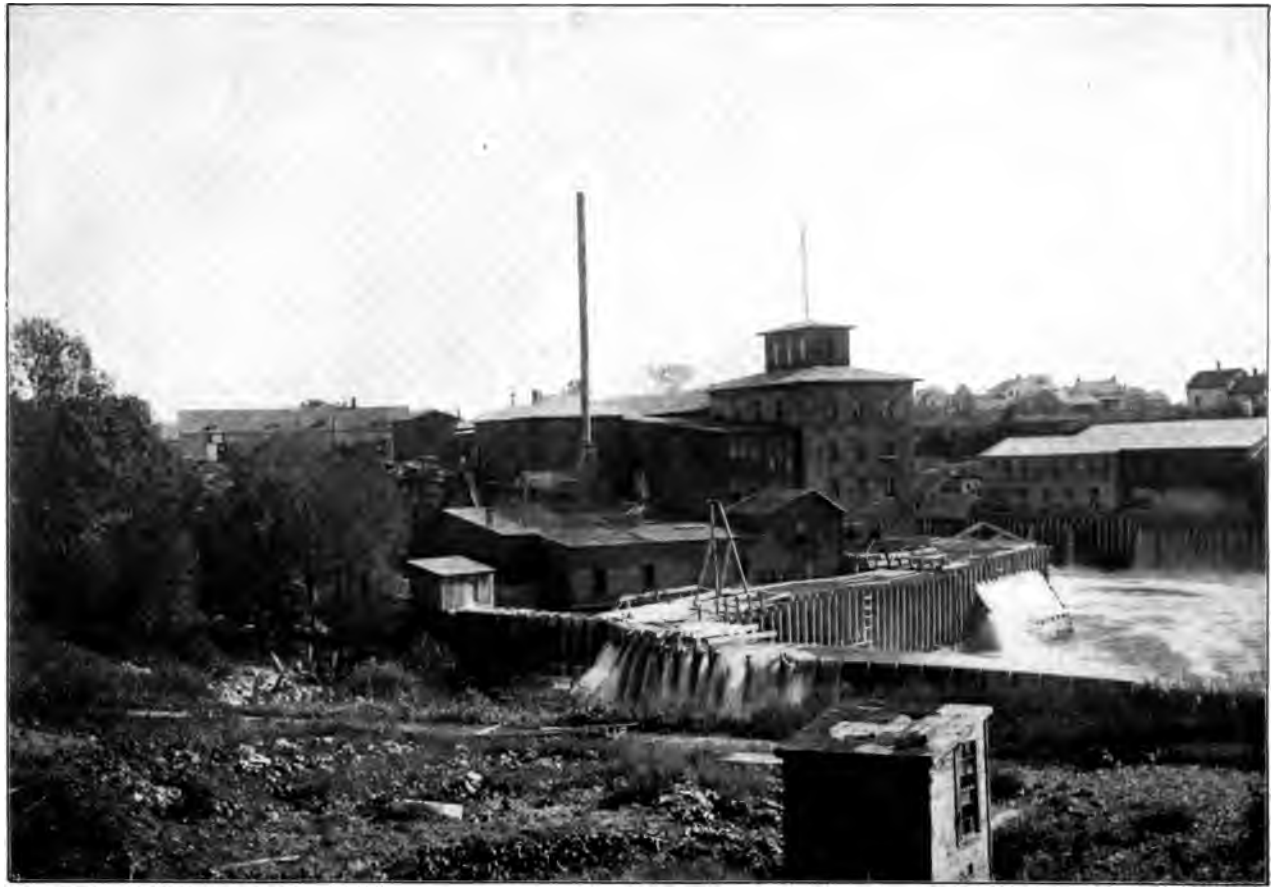


Photo by R. E. H.

THE NORTH SIDE MILL OF BROWNVILLE PAPER COMPANY.

TABLE NO. 128 A.—*Summary of the water power in use by classes of manufacture.*

Total number of establishments.	Class of manufacture.	Total amount of power in use (net horsepower).	Approximate total valuation of property.	Average valuation of property per net horsepower.	Approximate total value of annual product.	Average value of the annual product per net horsepower.	Average ratio of value of the annual product to valuation of property.	Total number of hands employed.	Average net horsepower in use per each hand employed.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
36	Pulp and paper	46,487	$5,303,500	$114.00	$5,242,620	$112.50	0.99	1,431	32.50
4	Carriages and wagons	1,876	621,000	331.00	2,095,000	1,117.00	3.40	703	2.60
8	Machine shops	377	344,900	915.00	651,500	1,728.00	1.90	343	1.10
9	Flour and feed mills	1,054	195,000	185.00	661,050	627.00	3.40	54	19.50
3	Electric light and power	1,014	140,000	137.00				16	63.40
2	Waterworks pumping station	1,688	130,000	77.00				*a* 3	562.70
8	Chairs and furniture	812	107,800	132.75	148,000	182.26	1.40	145	5.60
11	Sash, doors, blinds, lumber, and veneer	542	114,900	212.00	62,500	115.30		111	4.88
12	Miscellaneous	1,466	681,000	464.50	2,026,500	1,382.00		1,094	1.30
93	Total	55,316	7,638,000		10,887,170			3,900	

a This is at pumping station only.

Table showing total amount of water used for power when working at full capacity at each dam in cubic feet per second.

No. of dam.	Location of dam.	Water used for power, in cubic feet per second.
1	Dexter	*a* 2,303
2	Brownville	*a* 1,865
3	Above Brownville	*a* 1,244
4	Glen Park above Brownville	*a* 1,582
5	Remington Paper Co., below Watertown	*a* 1,724
6	Taggart's dam	*a* 1,227
7	Upper level Beebee's Island	*a* 1,796
8	Lower dam Sewall's Island	*b* 1,758
9	Upper dam Sewall's Island	*a* 2,166
10	Davidson Marble Co	198
11	Watertown waterworks	893
12	Watertown Paper Co	*a* 753
13	Black River	*a* 2,667
14	Felts Mills	*a* 1,583
15	Taggart Paper Co., Great Bend	*a* 917
16	Jefferson Power Co	*a* 1,096
17	West Carthage	*a* 1,009
18	Mill Island, Carthage	638
19	State dam, Carthage	*a* 1,221
20	Lyons Falls	*a* 1,326

a The location of pulp mills on all these dams explains the large excess development at most of them.
b One large flouring mill on this dam.

GENERAL SUMMARY.

Number of establishments	93
Total horsepower of water wheels in use	54,050
Total horsepower of engines in daily use	1,482
Total horsepower ordinarily in use	55,532
Total valuation of property	$7,638,100
Total value of annual product	$10,887,170
Total number of hands employed	3,900

In regard to the total of 53,834 net horsepower actually in use on Black River from Dexter to Lyons Falls, and including Beaver Falls on Beaver River, it may be remarked that probably the wheel manufacturers' ratings give generally higher results than are attained under actual working conditions. On the other hand, many of the water wheels on Black River have been set in the last few years and represent good recent water-wheel practice. If we compute the water actually used on these wheels as giving an average efficiency of 75 per cent, the total power included in Table No. 128 amounts to 49,797 net horsepower. The total gross horsepower of the water called for at the stated heads, as per Table No. 128, is 66,398.

The foregoing statistics as per Table No. 128 do not include the large development of the St. Regis Paper Company, a few miles below Carthage, now in process (August 1, 1899), and where wheels aggregating an additional 10,000 horsepower will be in service soon after January 1, 1900.

WATER POWER OF STREAMS TRIBUTARY TO BLACK RIVER FEEDER.

As shown on plate 93, there are a large number of streams crossing the proposed Black River feeder. Table No. 129, which gives statistics of water power in use on these streams, shows a total number of establishments of 60. As per column (12) of this table, the total value of the 60 establishments is $481,000, or the average value per establishment is $8,016.66. As per column (14), the value of the product of these several establishments is $888,250, or the average value per establishment is $14,804.17. The total number of hands employed is, as per column (17), 739. With the exception of the following, these establishments are mostly small and not of material influence on the prosperity of the communities in which they are situated. The exceptions noted are—

(1) Harden's chair factory, at McConnellsville, where the value of the annual product is given at $40,000 and 30 hands are employed.

(2) The Camden Knitting Company, at Camden, with a value of the annual product of $300,000 and 200 hands employed.

(3) The Camden Water Wheel Works, with an annual product of $65,000 and 20 hands employed.

(4) The A. W. Mott chair factory, at Camden, with an annual value of the product of $15,000 and 18 hands employed.

(5) F. H. Conant's Sons chair factory, on Mad River, at Camden, with a value of the annual product of $200,000 and 200 hands employed.

The total annual value of the product on Fish Creek is $465,400 and on Mad River at Camden $201,500.

(6) On Beaver Dam Brook, one-half mile above Altmar, we have the sawmill of the Horton Lumber Company, with an annual product of $17,500 and 10 hands employed.

TABLE No. 129.—*Water power in use on streams tributary to proposed Black River feeder in 1898.*

No. of dam.	No. of mill.	Name of stream.	Location of dam.	Owner or operator of mill.	Nature of business.	Ordinary working head, in feet.	Water used, in cubic feet per second.	Horsepower of water wheel at stated head and gate opening.	Gross power of water used as per column (7) and column (8) at theoretical efficiency.	Net power of water used, as per columns (7) and (8); efficiency of water wheels, 75 per cent.	Assumed valuation of property.	Valuation per horsepower of total power in use, as per column (7).	Value of the annual product.	Value of the annual product for each horsepower of total power in use.	Ratio of valuation of property to value of annual product.	Total number of hands employed.	Total horsepower in use for each hand employed.	Remarks.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
1	1	North Branch Sandy Creek.	Woodville	Wood Bros	Planing mill	7	29	11	23	17	$1,500	$136				3	3.7	
2	1	do	do	P. A. Osborne	Feed mill	11	64	60	80	60	3,000	50	$1,000	$17	.33	2	30	
3	1	do	do	H. D. Laird	Sawmill	9	35	18	36	27	350	19				1	18	
4	1	do	Belleville	W. R. Walsh	Gristmill	11	69	50	73	55	1,500	30				2	25	
4	1	do	do	J. E. Ray & Son	Sawmill	9	56	27	57	43	850	31				4	6.7	
		Total at Dam No. 4					125	77	130	98	2,350					6		
5	1	do	¼ mile above Belleville.	H. E. Phillips	Gristmill	18	65	41	82	61	8,000	195	1,000	24	.12	2	20.5	
6	1	do	Adams	A. G. Heath	Foundry	9	14	8	15	11	4,000	500				4	2	
6	1	do	do	Andrew Damon	Sawmill	6	12	4	8	6	2,000	500	2,000	500	1	3	1.3	
		Total at Dam No. 6					26	12	23	17	6,000		2,000			7		
7	1	do	do	E. J. Seever & Co.	Feed mill	12	42	49	57	43	15,000	306	25,000	510	1.67	4	12.2	

TABLE No 129.—*Water power in use on streams tributary to proposed Black River feeder in 1898*—Continued.

No. of dam.	No. of mill.	Name of stream.	Location of dam.	Owner or operator of mill.	Nature of business.	Ordinary working head, in feet.	Water used, in cubic feet per second.	Horsepower of water wheel at stated head and gate opening.	Gross power of water used as per column (7) and column (8) at theoretical efficiency.	Net power of water used, as per columns (7) and (8); efficiency of water wheels, 75 per cent.	Assumed valuation of property.	Valuation per horsepower of total power in use, as per column (7).	Value of the annual product.	Value of the annual product for each horsepower of total power in use.	Ratio of valuation of property to value of annual product.	Total number of hands employed.	Total horsepower in use for each hand employed.	Remarks.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
	1	North Branch Sandy Creek.	Adams	M. L. Pratt	Planing mill	12	35	38	48	36	$12,000	$316	$17,000	$447	1.42	6	47.5	Run mainly by steam power, by water only when there is a surplus.
8	2	do	do	R. F. Steele		12	83	95	114	86	5,000	53	......	......	......	2	.....	
		Total at Dam No. 8				....	118	133	162	122	17,000	.....	17,000	......	......	8	.....	
		Total North Branch Sandy Creek.				....	....	401	593	445	53,200	.....	46,000	......	......	33	.....	
1	1	South Branch Sandy Creek.	Ellisburg	A. P. Dennison	Gristmill	11	89	95	112	84	5,000	53	1,400	15	.28	2	47.5	
2	1	do	do	G. S. Hudson & Son.	Furniture	13	70	84	103	77	7,000	83	8,000	95	1.14	9	9.3	
3	1	do	7 miles above Ellisburg.	Arthur Lee	Feed and cider mill.	24	36	84	98	74	2,500	30	2,200	26	.89	2	42	

4	1	....do	Allendale	H. B. Rogers	Feed mill	11	146	146	182	186	2,500	17	2,000	14	.80	2	73	
		Total on South Branch Sandy Creek.						409	465	371	17,000		13,600			15		
1	1	Skinner Creek	Mannsville	O. J. Woodward	Feed and planing mill	23	192	50	67	50	7,000	140	6,000	120	.86	5	10	Has 6-horsepower engine.
2	1	....do	....do	F. Keller	Gristmill	10	56	32	64	48	8,000	250	3,000	94	.38	3	10.7	Has 40-horsepower engine for use during low water
		Total on Skinner Creek						82	131	98	15,000		9,000			8		
1	1	Little Sandy Creek.	Sandy Creek	Sandy Creek Manufacturing Co., Limited.	Woodenware	8	31	23	28	21	35,000	1,522	70,000	3,043	2.00	70	.3	
2	1	....do	....do	M. J. Salisbury	Gristmill	12	39	42	53	40	7,000	167				6	7	
3	1	....do		L. Baldwin	Planing mill	11	16	10	20	15	8,000	800				3	3.3	
4	1	....do		A. C. Skinkle	....do	6	48	29	36	27	3,500	121	5,000	172	1.42	3	9.7	
5	1	....do		S. H. Barlow	....do	8	37	27	33	25	5,000	185	15,000	556	3	5	5.4	
6	1	....do		W. B. Dixon	Sawmill	11	63	63	78	59	3,000	48	500	8	.17	3	21	
7	1	....do	Lacona	G. N. Harding	Gristmill	13	48	69	87	65	15,000	217				3	23	
8	1	....do	2 miles east of Lacona.	M. Woodard	Sawmill	16	40	47	59	44	800	17						Not in operation.
		Total on Little Sandy Creek						310	394	296	77,300							
1	1	Trout Brook	Centerville	A. D. Fillmore	Gristmill	13	40	50	60	45	4,000	80				2	25	
1	1	Salmon River	Pulaski	A. F. Betts	Electric lighting.	10	119	109	135	101	8,000	13				2	54.5	Have a 60-horsepower engine.
1	2	....do	....do	R. W. Box	Furniture	9	31	27	32	24	7,000	259	10,000	370	143	8	3.4	
		Total at Dam No. 1					150	138	167	125	15,000		10,000			10		
2	1	Salmon River	Pulaski	A. D. Fillmore	Gristmill	4	110	30	50	38	4,500	150	2,400	80	.53	2	15	
3	1	....do	....do	F. E Hohman	....do	9	50	31	52	39	4,500	145	3,000	97	.67	2	15.5	
3	2	....do	....do	John F. Box	Planing and cider mill.	5	29	10	17	13	3,000	300	3,000	300	1	6	1.7	
3	3	....do	....do	Maltby & Street	Sawmill	5	69	24	40	30	2,500	104	3,000	125	1.20	6	4	
3	4	....do	....do	Wilder Manufacturing Co.	Wagon factory.	4	19	5	8	6	1,000	200				4	1.2	
		Total at Dam No. 3					167	70	117	88	11,000		9,000			18		
4	1	Salmon River	Pulaski	Ontario Iron Works.	Engines and machinery.	10	13	12	14	11	16,000	133				8	1.5	Steam power used in emergency.
4	2	....do	....do	Joseph Clark	Ladder factory.	13	24	21	35	26	2,500	119	10,000	476	4	4	5.2	
4	3	....do	....do	Mahaffy Bros	Woolen mill	12	18	15	24	18	2,000	133				5	3	
4	4	....do	....do	Siemens & Nickel	Planing mill	12	37	30	50	38	2,000	67	7,000	233	3.50	3	10	
4	5	....do	....do	Oscar Clark	Butter-tub factory.	4	6	2	3	2	1,000	500	400	200	.20	1	2	

TABLE No. 129.—*Water power in use on streams tributary to proposed Black River feeder in 1898*—**Continued.**

No. of dam.	No. of mill.	Name of stream.	Location of dam.	Owner or operator of mill.	Nature of business.	Ordinary working head, in feet.	Water used in cubic feet per second.	Horsepower of water wheel at stated head and gate opening.	Gross power of water used as per column (7) and column (8) at theoretical efficiency.	Net power of water used as per columns (7) and (8): efficiency of water wheels, 75 per cent.	Assumed valuation of property.	Valuation per horsepower of total power in use, as per column (7).	Value of the annual product.	Value of the annual product for each horsepower of total power in use.	Ratio of valuation of property to value of annual product.	Total number of hands employed.	Total horsepower in use for each hand employed.	Remarks.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
4	6	Salmon River ...	Pulaski	Wm. Lane	Wood turning.	5	5	2	3	2	$500	$250	....	....	......	1	2	
		Total at Dam No. 4				...	103	82	129	97	24,500	....	$17,400	......	......	22	....	
5	2	Salmon River....	Altmar	Post & Henderson.	Gristmill	7	172	114	138	102	5,000	45	4,200	$57	.84	2	57	
5	2	.....do	.....do	Haggard & Gleason.	Planing mill	5	14	5	8	6	2,500	179	1,000	200	.40	2	2.5	
		Total at Dam No. 5				....	186	119	144	108	7,500	...	5,200	......	......	4	.....	
6	1	Salmon River....	2 miles above Altmar.	D. Lassall	Sawmill......	6	15	6	10	7	700	117	750	125	1.07	4	1.5	
		Total on Salmon River.........				....	....	443	617	463	62,700	...	44,750	......	......	60	....	
1	1	Beaver Dam Brook.	¼ mile above Altmar.	Norton Lumber Co.	Sawmill......	12	52	43	71	53	13,000	302	17,500	407	1.35	10	43	

1	1	Mad River	Camden	Jackson & Payne	Gristmill	9	82	70	84	63	9,000	129	1,500	21	.17	2	35	
2	1	do	do	F. H Conants' Sons	Chair factory	8	47	36	43	32	58,000	1,611	200,000	5,500	3.45	200	.2	Have a 150-horsepower engine in continuous use.
		Total on Mad River				....	....	106	127	95	67,000	.....	201,500	......	......	202	....	
1	1	West Branch Fish Creek.	McConnellsville	Chas. Harden	Sawmill and gristmill.	6	112	63	76	57	5,000	79	6,000	95	1.20	10	6.3	
1	2	do	do	Frank S. Harden	Chair factory	6	85	48	58	43	22,000	451	40,000	930	1.85	30	1.6	
		Total at Dam No. 1				....	197	111	134	100	27,000	.....	46,000	......	......	40	....	
2	1	West Branch Fish Creek.	Camden	W. H. Gillis	Sawmill	9	50	25	51	38	2,500	100	2,000	80	.80	6	4.2	
2	2	do	do	Lewis Perrin	Furniture factory.	8	23	13	21	16	3,500	269	5,000	385	1.43	5	2.6	
2	3	do	do	Gardner Dana	Sash and blinds.	8	61	47	56	42	4,000	85	10,000	213	2.50	6	7.8	A 25-horsepower engine used during low water.
2	4	do	do	H. J. Rush	do	7	44	29	35	26	6,000	207	5,500	190	.92	5	5.8	A 35-horsepower engine used during low water.
		Total, lower dam at Camden				....	178	114	163	122	16,000	.....	22,500	......	......	22	....	
3	1	West Branch Fish Creek.	Camden	Camden Knitting Co.	Knitting mill.	10	102	97	115	86	50,000	515	300,000	3,093	6	200	.5	
3	2	do	do	Camden Water Wheel Works.	Water wheels	9	45	39	46	35	40,000	1,025	65,000	1,667	1.62	20	2	
		Total at Dam No. 3				....	147	136	161	121	90,000	.....	365,000	......	......	220	....	
4	1	West Branch Fish Creek.	Camden	Penfield & Stone	Gristmill	10	195	157	221	166	15,000	96	3,000	19	.20	2	78.5	
5	1	do	1 mile above Camden.	John Dorance	Sawmill	5	112	53	64	48	500	9	6,000	113	12	2	26.5	
6	1	do	West Camden	A. W. Mott	Chair factory	5	41	19	23	17	7,000	152	15,000	79	2.14	18	1	
6	2	do	do	C. E. Mott	Grist and saw mill.	5	156	73	88	66	7,000	96	6,000	82	.86	3	24.3	
		Total at Dam No. 6				....	197	92	111	83	14,000	.....	21,000	......	......	21	....	
7	1	West Branch Fish Creek.	Williamstown	M. Windsor	Sawmill	16	33	44	58	43	800	18	1,000	23	1.25	3	14.7	
7	2	do	do	P. W. Kellar	Gristmill	16	15	22	28	21	6,000	271	......	......	......	2	11	
		Total at Dam No. 7				....	48	66	86	64	6,800	.....	1,000	......	......	5	....	
8	1	West Branch Fish Creek.	Williamstown	Thomas Laing	Gristmill	9	193	185	197	148	2,500	13	900	5	.36	4	46.2	
		Total on West Branch Fish Creek.				....	....	914	1,137	852	171,800	.....	465,400	......	......	316	....	
	60	Total on streams crossed by proposed feeder.				....	....	2,758	3,625	2,718	481,000	.....	888,250	......	......	739	....	

(7) On Little Sandy Creek, at the village of Sandy Creek, the Sandy Creek Manufacturing Company, Limited, manufacturers of wooden ware, turn out an annual product of $70,000 and employ 70 hands.

(8) The S. H. Barlow planing mill, at Sandy Creek, turns out an annual product of $15,000 and employs 5 hands.

(9) At Ellisburg G. S. Hudson & Son turn out an annual product of $8,000 at their furniture factory and employ 9 hands.

(10) At Adams E. G. Seever & Co. turn out an annual product of $25,000 at their feed mill, employing 4 hands.

(11) The M. L. Pratt planing mill, at Adams, has an annual product of $17,000 and employs 6 hands.

As stated on a previous page, the streams to the north of Trout Brook were in August, 1898, all practically dry. If the Black River feeder is ever constructed, the percolation loss therefrom, amounting, as shown in the chapter discussing that feeder, for the streams between Sandy Creek and Kasoag to possibly 230 cubic feet per second, will necessarily flow into these several streams, tending to materially increase their low-water summer flow. Even after the feeder line has been in operation for several years, the percolation loss will undoubtedly be far in excess of the summer flow of these streams in their natural state. It is true, however, that we have no means of determining just what the effect is on each stream. Nevertheless, it has seemed to the author that the net result would be, on the whole, in favor of the streams, the more especially since during the winter months there is no reason why the natural flow of the streams should not be disdischarged into them, thus leaving them in their present condition. Moreover, the preceding discussion shows that for a considerable portion of the navigation season of each year the water supply, as a whole, is so far in excess of actual requirements that the flow of these streams can be kept high enough to meet existing conditions. From this point of view, therefore, no allowance has been made for damages to water power on any of these streams, the author's proposition being that existing water powers will be improved rather than injured. But in order to prove this latter proposition, it is deemed important, in case construction should ever be ordered, that gaugings of these streams be immediately instituted in order to certainly show the truth or falsity of this view.

On the West Branch of Fish Creek somewhat different conditions obtain. During certain months of the navigation season additions to the flow of this stream, amounting at times to as much as 1,200 cubic feet per second, are likely to be made. A number of the dams on West Branch of Fish Creek are poorly constructed, and it is doubtful if they would pass the quantity required for feeding the canal, in addition to the possible flood flows, without injury to the dams. It has therefore been deemed proper to make an addition to the estimates large enough to compensate the owners for the existing structures, leaving them free to build new structures adequate to the changed conditions, but without any claim for damages on account of the increased flow, as given in detail on a preceding page. As a matter of fact, the water power of West Branch of Fish Creek will be greatly improved during the navigation months, April to November, inclusive, but the uncertainty as to just the quantity of water to be added to that stream each month and the fact that in years of ample rainfall there may be only two months in which any addition will be made other than that from Salmon River reservoir, renders it impossible to say how much the permanent water power of the stream is improved. It appears probable, therefore, that the mill owners would be justly entitled to damages for whatever expense they are obliged to incur on account of strengthening the dams.

Statistics as to value of the properties per horsepower, value of the annual product per horsepower, and horsepower per hand employed are also given in Table No. 129.

EFFICIENCY OF WATER WHEELS.

In Table No. 128, showing water power in use on Black River in 1898, column (6) gives the quantity of water used at each mill, as deduced from statements made as to gate opening, etc., by the proprietors. Inasmuch as the quantities of column (6) are based on either the ratings of manufacturers of water wheels, as given in their trade catalogues, or on the data of tests obtained from Holyoke (so far as the same apply), the question may be appropriately asked whether the totals, as per column (6) of Table No. 128, are not somewhat in excess of the truth, and that, consequently, the proposed allowance of 2,200 cubic feet per second constant flow of Black River is not larger than necessary to meet existing conditions. The matter may be looked at in two ways. We may say, on the one hand, that the manufacturers of water wheels show no greater use of water than necessary to produce a tabulated power, as per wheel catalogue, at the stated efficiency, or, on the other hand, that the tendency under fierce commercial competition has been, in recent years, to reduce size of wheel and consequently the weight, at the same time tabulating as much water and power as the circumstances of each case will admit. Probably these two tendencies have produced a balance of conditions which, on the whole, is very well represented by the figures tabulated in column (6) of Table No. 128, and which, therefore, may be fairly taken as not far from the truth. At any rate, whichever view is correct, there is no ready way of obtaining the quantity of water required at each mill in those cases where the Holyoke tests do not apply other than to take stated discharge, as per water-wheel catalogue. As a matter of judgment purely, it is deemed probable that if we assume stated heads as approximately correct the resulting error would not exceed 10 per cent.

Column (7) of Table No. 128 gives the actual horsepower of water wheels at stated head and gate opening, as computed from the Holyoke data, so far as this applies; otherwise from the manufacturers' wheel catalogues. The total of column (7) is 54,050 horsepower.

Column (7a) gives gross horsepower of water used, as per columns (5) and (6), at the theoretical efficiency of the water. The total of this column is 66,398.

In column (7b) we have the net power of the water used, as per columns (5) and (6), with the efficiency assumed at 75 per cent of the theoretical. The total of column (7b) is 49,797.

Taking into account that a very large proportion of the plants on Black River are new, and that many of the water wheels are of the best design and efficiency, it is probable that the total of column (7) of 54,050 horsepower is not very far from the actual power developed. At any rate, it seems safe to assume that the true total will lie somewhere between the footing of column (7) and (7b). If we take the means of these two columns, we have a total of 51,424 net horsepower. For even figures we may say that the total net horsepower in use on Black River in the fall of 1898 was 52,000.

ESTIMATED VALUE OF WATER POWER PER HORSEPOWER.

In Water Supply and Irrigation Paper No. 25, of the United States Geological Survey—Water Resources of the State of New York, Part 2, page 189—the author has stated that the value of water per gross horsepower, when used at first hand in manufacturing, may be taken at about $100 per horsepower per year. This is a general estimate for all kinds of manufacturing and for all localities in the State. For use in paper making, which is the chief industry of Black River, the figure deduced from the statistics of 36 pulp and paper mills in Table No. 128 is $198.50 per horsepower per year. These figures do not mean that the mere possession of the water represents values of from $198.50 to $100 per year per horsepower, but that the developed plants with invested capital will yield annual products per horsepower per year averaging something like $100 to $200 for different kinds of manufacturing business. Taking all the mills on Black River as they stood in the fall of 1898, with the stated value of the annual product of $10,877,170 and 66,398 gross horsepower in use, the value per gross horsepower per year becomes, roundly, $164. For other streams with different character of business from that on Black River, these figures would be quite different.

BLACK RIVER RESERVOIR.

In general terms this project includes the construction of a main barrage across Black River at the village of Carthage, by which the ordinary water surface of that stream will be raised 48.5 feet and an area flooded at extreme high water of 77.9 square miles, or 49,856 acres. In the estimates the total quantity of land is taken at 50,000 acres, of which 49,200 acres are agricultural, timber, and wild lands, 800 acres being villages and the suburbs thereof. The area flooded at elevation of spillway crest, 772 feet above tide water, is 73.2 square miles. The catchment area of Black River at Carthage is 1,812.2 square miles. In addition to the main barrage across the channel of Black River, there are seven dikes to be constructed in the vicinity of Carthage across lateral valleys. The project also includes the relocation of nearly 20 miles of the New York Central and Hudson River Railway (Rome, Watertown and Ogdensburg Division), together with the raising of several miles of the same without change of the present location; the construction of three highways across the reservoir to take the place of existing highways; the reconstruction of highways along the margins; the partial or complete removal of the villages of Beaver Falls, Bushee's Landing, Carthage, Castorland, Dadville, Deer River, East Martinsburg, Glenfield, Lowville, Naumburg, New Bremen, and Watsons. At Carthage and Lowville, the two large villages of the area proposed to be flooded, the submerged areas are relatively unimportant parts of the towns. Several of the other villages are entirely submerged, while others are only partially submerged.

There are eight cemeteries within the limits of the flow line, including 26.2 acres area. Three of these are small family burying places, while the others are used by the communities in the vicinity. In regard to a wholesale removal of cemeteries, such as is here contemplated, it may be pointed out that while probably this is the most delicate of the several changes to be made, still in view of the fact that the removal of cemeteries in order to make place for public improvements is very common in the State of New York, there is no reason why these cemeteries should not be moved in the present case. Cemeteries have been moved in the State of New York for various purposes at Rochester, Albany, Brooklyn, New York City, in the valley of the Croton River, and at other places. The author has discussed this phase of the reservoir problem at length in his report on Genesee River storage in the Annual Report of the State Engineer and Surveyor of the State of New York for the fiscal year ending September 30, 1896, and is unable to add anything to what has been said in that report, to which the reader is referred for further detail. The problem of changing a considerable extent of railway for the construction of a large reservoir is also discussed somewhat at length in the same report.

There are 807 dwellings, 14 common schoolhouses, and 9 churches within flow line. The work also includes 17.2 miles of new common roads, in addition to the three highway crossings over reservoir previously mentioned.

At present there are five bridges over Black River between Carthage and Lyons Falls, namely: Castorland, 1; Lowville, 2; Glenfield, 1; Greig, 1. It is considered that the three crossings as proposed will fairly accommodate the traffic of the region.

The Black River Valley between Carthage and foot of Lyons Falls is a broad, nearly level valley, in some places about 5 miles in width, gradually narrowing to a width of about one-half a mile in the upper portion. According to the Black River Canal levels, the crest of the State dam at Carthage is at an elevation of 723.53 feet above tide water, while the water surface at Lyons Falls, 42.5 miles distant by the meander of the river, is, according to the same levels, 735.65. At present the slack-water navigation from Lyons Falls to Carthage is made by two dams with locks, one at Otter Creek with a lift of about 4 feet and one at Bushee's Landing with a lift of about 4.5 feet. From Lyons Falls the Black River Canal rises to the Boonville summit, where the elevation of the summit level is 1,126.96 feet above tide in a distance of 10 miles. From Boonville, Black River Canal drops down to Erie Canal level at Rome, a distance of 25 miles. This discussion of Black River reservoir is made on the basis that, in case of carrying out deep waterways in the final arrangements with the State of New York, the Black River Canal would be abandoned.

That portion of Black River Valley within the flow line of the proposed reservoir presents considerable diversity of soil. In the lower portion the soils to the east of the river are, in a large degree, sandy and of very little value for agriculture, while on the west side there are considerable areas of valuable bottom meadows. To the east and southeast of Carthage there are also extensive areas almost entirely covered with rock, and of very nominal value. The values of these different grades of lands, determined by consultation with the assessors of the several townships in which they are situated, are shown in detail in the accompanying estimates. The following notes, as obtained from assessors in a few of the townships affected, are cited as showing the values of these lands:

In the town of Denmark the assessors state that hill farms are valued at $20 per acre, flats at from $60 to $70. These the assessors consider to be nearly full values.

In the town of Croghan the assessors value the best farms in the flats at $37 per acre, and other lands at from $6 to $25 per acre. The rock and sand areas at from $2 to $5 per acre.

In the town of New Bremen the equalized assessed value per acre for the whole township is $8.25. The assessors state that this is about 60 per cent of value. On this basis the average value of lands in that township becomes $13.75 per acre.

In Greig Township the assessors state that good river flats are assessed at $25 per acre; sandy flats at from $6 to $7 per acre; the best stony land at $12 per acre; poor stony land at $7 per acre, and swamps at 50 cents per acre.

In Martinsburg Township the best flat lands are assessed at from $30 to $35 per acre; swamps at $1 per acre. The equalized value per acre in this township, as per supervisors' equalization table for 1898, is $22.65.

In Lowville Township, river flats and all lands between New York Central and Hudson River Railway and the river are assessed at $50 an acre. The equalized value in this township is $66.50.

In the town of Turin flats are assessed at $40 per acre, and lands on the first bench above the flats at $30 per acre.

Referring to the supervisors' equalization table in the Proceedings of the Board of Supervisors of Lewis County, it is learned that the total assessed area in Lewis County is 754,488 acres, on which the assessors place a total value of $8,834,204. At this rate the average price per acre for the whole county becomes $11.71.

As shown by the detailed estimates, the total value of the 50,000 acres of land to be taken for Black River reservoir is estimated at $1,876,000. By way of proving that this is an ample estimate we may consider that while 50,000 acres is only about one-fifteenth of the total area of Lewis County, the estimated value of $1,876,000 is about one-fifth of the total valuation of the county; that is to say, the estimated value of the lands to be taken is nearly three times the average value of the lands of the whole county. The lands to be taken include, however, some of the best in the county, as well as a large proportion of the poorest lands.

Probably as serious a consequence as any to result from the construction of Black River reservoir is the considerable interference with the water power at Beaver Falls, Lyons Falls, New Bremen, Lowville, Fentons Mills, and Deer River Village. At Beaver Falls, on Beaver River, there are now four establishments ordinarily using 3,071 horsepower and with a total valuation of $425,000, the total value of the annual product being $448,600. There are 42 hands employed. The first of these establishments is the J. P. Lewis Pulp and Paper Company, manufacturing wood pulp and pulp boards and mats; the second is the J. P. Lewis Company, manufacturing wood pulp; the third is Lewis & Slocum, manufacturing wood-pulp board, and the fourth, Lewis, Slocum & Lefebre, manufacturing wood pulp. The first three of these establishments will be entirely eliminated, the backwater of Black River reservoir just about reaching the crest of the Lewis & Slocum dam. The water-power statistics of these several establishments are given in Table No. 128.

At Lyons Falls we have the custom feed mill of H. C. Markham, who was also in the fall of 1888 erecting a small electric-light plant for lighting the village of Lyons Falls. These establishments are situated on Black River Canal, just above where the said canal enters Black River, and will be entirely submerged. The value, however, is small, not exceeding $5,000. The principal establishment at Lyons Falls is the newspaper mill of the Gould Paper Company, where the water wheels ordinarily work under from 67 to 68 feet head, yielding a power of something like 7,731 horsepower. The crest of the power dam above the falls is at an elevation of 801 above tide water, while the crest of the barrage at Carthage will be placed, as stated, at 772 above tide water. There will remain, then, when the reservoir is just full, 29 feet head instead of about 68, as at present. During such flood flows as occur, with the water surface of the reservoir above crest of barrage at Carthage, the head will be less, although, as shown by column 10 of Table No. 131, this condition will only rarely occur. Usually, with the reservoir drawn somewhat down, the head at Lyons Falls will be, on an average, from 30 to 35 feet. In any case the mill will largely require reconstructing in order to conform to the new conditions, and from this point of view the damages have been liberally estimated. The Gould Company were expending about $200,000 on improvements to their mill during the summer of 1899.

At Deer River Village the backwater of the reservoir just about reaches the crest of the lower dam, practically eliminating water power at that dam.

At Lowville there is an old mill the water power of which will be destroyed.

At New Bremen there are three small establishments entirely submerged.

At Fentons Mill, on the east side of the reservoir, a small feed mill will be submerged.

The chief damage will occur at Beaver Falls and Lyons Falls, the mills at the other places being relatively unimportant.

TABLE No. 130.—*Showing area flowed, volume stored, and corresponding inches in depth on catchment area for successive elevations of water surface in the proposed Black River reservoir.*

Elevation of water surface.	Area of water surface.	Volume.	Inches on catchment area of 1,812.2 square miles.
(1)	(2)	(3)	(4)
	Sq. miles.	*Cubic feet.*	
730	10.819		
731	13.105	620,188,060	0.1473
732	15.391	1,240,376,120	0.2946
733	17.677	1,860,564,180	0.4419
734	19.963	2,480,752,240	0.5892
735	22.249	3,100,940,300	0.7365
736	24.535	3,721,128,360	0.8838
737	26.821	4,341,316,420	1.0311
738	29.107	4,961,504,480	1.1784
739	31.393	5,581,692,540	1.3257
740	33.676	6,201,880,600	1.4729
741	35.624	7,412,282,320	1.7604
742	37.572	8,622,684,040	2.0479
743	39.520	9,833,085,760	2.3354
744	41.468	11,043,487,480	2.6229
745	43.416	12,253,889,200	2.9104
746	45.364	13,464,290,920	3.1979
747	47.312	14,674,692,640	3.4855
748	49.260	15,885,094,360	3.7730
749	51.208	17,095,496,080	4.0606
750	53.157	18,305,897,800	4.3481
751	54.066	19,914,633,940	4.7302
752	54.975	21,523,370,080	5.1123
753	35.884	23,132,106,220	5.4944
754	56.793	24,740,842,360	5.8765
755	57.702	26,349,578,500	6.2586
756	58.611	27,958,314,640	6.6407
757	59.520	29,567,050,780	7.0228
758	60.429	31,175,786,920	7.4049
759	61.339	32,784,523,060	7.7871
760	62.250	34,393,259,200	8.1692
761	63.184	36,258,912,220	8.6123
762	64.118	38,124,565,240	9.0554
763	65.052	39,990,218,260	9.4985
764	65.986	41,855,871,280	9.9416
765	66.920	43,721,524,300	10.3847
766	67.854	45,587,177,320	10.8279
767	68.788	47,452,830,340	11.2710
768	69.722	49,318,483,360	11.7141
769	70.656	51,184,136,380	12.1572
770	71.590	53,049,789,400	12.6005
771	72.374	55,154,913,520	13.1005
772	73.158	57,260,037,640	13.6005
773	73.942	59,365,161,760	
774	74.726	61,470,285,880	
775	75.510	63,575,410,000	
776	76.294	65,680,534,120	
777	77.078	67,785,658,240	
78	77.862	69,890,782,360	

Table No. 131.—*Showing state of proposed Black River reservoir from month to month, 1892 to 1898, inclusive, with draft therefrom as per column (10) of Table No. 134, and with 2,200 cubic feet per second going to Black River.*

[In inches on the tributary catchment area of 1,812.2 square miles.]

Month.	Run-off. Inflow to reservoir.	Outgo from reservoir. Evaporation.	Outgo from reservoir. 2,200 cubic feet per second.	Outgo from reservoir. To canal.	Outgo from reservoir. Total outgo.	Excess.	Deficiency.	In reservoir at end of month.	Wasted from reservoir.	Elevation of surface of reservoir at end of month.	Contents of reservoir at end of month.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1892.											
December	2.27	0.05	1.40	....	1.45	0.82	....	0.82	....	735.60	3,475,000,000
January	4.83	0.02	1.40	....	1.42	3.41	....	4.23	....	749.50	17,700,000,000
February	2.22	0.03	1.26	....	1.29	0.93	....	5.16	....	752.10	21,680,000,000
March	2.80	0.06	1.40	....	1.46	1.34	....	6.50	....	755.00	27,300,000,000
April	5.35	0.11	1.35	....	1.46	3.89	....	10.30	....	765.08	43,722,000,000
May	5.03	0.14	1.40	....	1.54	3.49	....	13.50	0.38	771.80	56,734,000,000
June	3.08	0.18	1.35	....	1.53	1.55	....	13.50	1.55	771.80	56,734,000,000
July	2.38	0.24	1.40	....	1.64	0.74	....	13.50	0.74	771.80	56,734,000,000
August	1.41	0.19	1.40	....	1.59	....	0.18	13.32	....	771.40	56,000,000,000
September	1.10	0.17	1.35	0.37	1.89	....	0.79	12.53	....	769.80	52,650,000,000
October	0.72	0.11	1.40	0.50	2.01	....	1.29	11.24	....	767.00	47,453,000,000
November	1.89	0.06	1.35	....	1.41	0.48	....	11.72	....	768.00	49,318,000,000
Total	33.08	1.36	16.46	0.87	18.60	....	....	....	2.67	....	....
1893.											
December	1.03	0.05	1.40	....	1.45	....	0.42	11.30	....	767.10	47,639,000,000
January	0.82	0.02	1.40	....	1.42	....	0.60	10.70	....	765.70	45,010,000,000
February	1.09	0.03	1.26	....	1.29	....	0.20	10.50	....	765.30	44,285,000,000
March	2.11	0.06	1.40	....	1.46	0.65	....	11.15	....	766.70	46,870,000,000
April	4.44	0.11	1.35	....	1.46	2.98	....	13.50	0.63	771.80	56,734,000,000
May	5.71	0.13	1.40	....	1.53	4.18	....	13.50	4.18	771.80	56,734,000,000
June	1.19	0.18	1.35	0.30	1.83	....	0.64	12.86	....	770.50	54,115,000,000
July	0.65	0.23	1.40	0.51	2.14	....	1.49	11.37	....	767.20	47,829,000,000
August	1.28	0.20	1.40	0.30	1.90	....	0.62	10.75	....	765.80	45,175,000,000
September	1.70	0.12	1.35	0.27	1.74	....	0.04	10.71	....	765.70	45,010,000,000
October	0.99	0.11	1.40	0.49	2.00	....	1.01	9.70	....	763.50	46,922,000,000
November	0.90	0.06	1.35	0.43	1.84	....	0.94	8.76	....	761.30	36,800,000,000
Total	21.91	1.30	16.46	2.30	20.06	....	....	....	4.81	....	....
1894.											
December	1.85	0.05	1.40	....	1.45	0.40	....	9.16	....	762.30	38,700,000,000
January	1.73	0.02	1.40	....	1.42	0.31	....	9.47	....	763.00	40,000,000,000
February	1.12	0.03	1.26	....	1.29	....	0.17	9.30	....	762.60	39,255,000,000

March	3.78	0.08	1.40	....	1.46	2.32	....	11.62	....	767.80	48,930,000,000
April	2.76	0.10	1.35	....	1.45	1.31	....	12.93	....	770.60	54,310,000,000
May	1.94	0.13	1.40	....	1.53	0.41	....	13.34	....	771.50	56,180,000,000
June	1.76	0.14	1.35	....	1.49	0.27	....	13.50	0.11	771.80	56,734,000,000
July	0.81	0.21	1.40	0.52	2.13	....	1.32	12.18	....	769.10	51,340,000,000
August	0.63	0.25	1.40	0.55	2.20	....	1.57	10.61	....	765.50	44,635,000,000
September	0.47	0.14	1.35	0.30	1.79	....	1.32	9.20	....	762.50	39,075,000,000
October	0.94	0.10	1.40	0.36	1.86	....	0.92	8.37	....	760.50	35,300,000,000
November	1.58	0.05	1.35	....	1.40	0.18	....	8.55	....	760.90	36,072,000,000
Total	19.37	1.28	16.46	1.73	19.47	....	....	....	0.11	....	....
1895.											
December	1.12	0.05	1.40	....	1.45	....	0.33	8.22	....	760.10	34,550,000,000
January	0.99	0.02	1.40	....	1.42	....	0.43	7.79	....	759.30	33,230,000,000
February	0.82	0.03	1.26	....	1.29	....	0.47	7.32	....	757.80	30,830,000,000
March	1.08	0.06	1.40	....	1.46	....	0.38	6.94	....	756.80	29,225,000,000
April	5.91	0.10	1.35	....	1.45	4.46	....	11.40	....	767.30	47,900,000,000
May	1.76	0.12	1.40	0.22	1.74	0.02	....	11.42	....	767.32	48,020,000,000
June	0.70	0.20	1.35	0.53	2.08	....	1.38	10.04	....	764.20	42,180,000,000
July	0.66	0.21	1.40	0.60	2.21	....	1.55	8.49	....	760.70	35,670,000,000
August	1.00	0.19	1.40	0.47	2.06	....	1.06	7.43	....	758.10	31,318,000,000
September	0.65	0.10	1.35	0.56	2.10	....	1.45	5.98	....	754.30	25,200,000,000
October	0.69	0.12	1.40	0.58	2.10	....	1.41	4.57	....	750.60	19,280,000,000
November	2.08	0.04	1.35	....	1.39	0.69	....	5.26	....	752.40	22,175,000,000
Total	17.46	1.33	16.46	2.96	20.75	....	....	....	....	....	....
1896.											
December	2.79	0.04	1.40	....	1.44	1.35	....	6.61	....	755.90	27,797,000,000
January	1.74	0.02	1.40	....	1.42	0.32	....	6.93	....	756.80	29,225,000,000
February	1.12	0.02	1.26	....	1.28	....	0.16	6.77	....	756.30	28,438,000,000
March	3.49	0.03	1.40	....	1.43	2.06	....	8.83	....	761.30	36,800,000,000
April	6.20	0.10	1.35	....	1.45	4.75	....	13.50	0.08	771.80	56,734,000,000
May	1.18	0.20	1.40	0.40	2.00	....	0.82	12.68	....	770.10	53,275,000,000
June	1.18	0.20	1.35	0.29	1.84	....	0.66	12.02	....	768.70	50,618,000,000
July	0.72	0.17	1.40	0.52	2.09	....	1.37	10.65	....	765.60	44,985,000,000
August	0.63	0.18	1.40	0.56	2.14	....	1.51	9.14	....	762.20	38,475,000,000
September	0.71	0.12	1.35	0.56	2.03	....	1.32	7.82	....	759.10	32,915,000,000
October	1.05	0.08	1.40	....	1.48	....	0.43	7.39	....	758.00	31,176,000,000
November	2.82	0.05	1.35	....	1.40	1.42	....	8.81	....	761.50	37,175,000,000
Total	23.63	1.21	16.46	2.33	20.00	....	....	....	0.08	....	....
1897.											
December	1.77	0.05	1.40	....	1.45	0.32	....	9.13	....	762.20	38,475,000,000
January	1.03	0.02	1.40	....	1.42	....	0.39	8.74	....	761.30	36,800,000,000
February	0.90	0.03	1.26	....	1.29	....	0.39	8.35	....	760.50	35,300,000,000
March	4.07	0.07	1.40	....	1.47	2.60	....	10.95	....	766.30	46,118,000,000
April	5.44	0.10	1.35	....	1.45	3.99	....	13.50	1.44	771.80	56,734,000,000
May	4.97	0.13	1.40	....	1.53	3.44	....	13.50	3.44	771.80	56,734,000,000
June	1.74	0.19	1.35	....	1.54	0.20	....	13.50	0.20	771.80	56,734,000,000

TABLE NO. 131.—*Showing state of proposed Black River reservoir from month to month, 1892 to 1898, inclusive, with draft therefrom as per column (10) of Table No. 134, and with 2,200 cubic feet per second going to Black River*—Continued.

Month.	Run-off. Inflow to reservoir.	Outgo from reservoir.				Excess.	Deficiency.	In reservoir at end of month.	Wasted from reservoir.	Elevation of surface of reservoir at end of month.	Contents of reservoir at end of month.
		Evaporation.	2,200 cubic feet per second.	To canal.	Total outgo.						
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1897.											
July	0.74	0.17	1.40		1.57		0.83	12.67		770.10	53,275,000,000
August	1.44	0.20	1.40		1.60		0.16	12.51		769.80	52,650,000,000
September	0.68	0.18	1.35	0.57	2.10		1.42	11.09		766.60	46,680,000,000
October	0.65	0.12	1.40	0.54	2.06		1.41	9.68		763.40	40,712,000,000
November	2.56	0.05	1.35		1.40	1.16		10.84		765.80	45,175,000,000
Total	25.99	1.31	16.46	1.11	18.88				5.08		
1898.											
December	3.17	0.04	1.40		1.44	1.73		12.57		769.90	52,840,000,000
January	2.35	0.02	1.40		1.42	0.93		13.50		771.80	56,734,000,000
February	2.24	0.04	1.26		1.30	0.94		13.50	0.94	771.80	56,734,000,000
March	6.63	0.06	1.40		1.46	5.17		13.50	5.17	771.80	56,734,000,000
April	3.20	0.13	1.35		1.48	1.72		13.50	1.72	771.80	56,734,000,000
May	2.25	0.15	1.40		1.55	0.70		13.50	0.70	771.80	56,734,000,000
June	1.15	0.23	1.35	0.08	1.66		0.51	12.99		770.80	54,825,000,000
July	0.87	0.26	1.40	0.45	2.11		1.24	11.75		768.10	49,492,000,000
August	1.07	0.19	1.40	0.11	1.70		0.63	11.12		766.70	46,870,000,000
September	1.02	0.15	1.35	0.33	4.83		0.81	10.31		764.90	43,500,000,000
October	2.16	0.10	1.40		1.50	0.66		10.97		766.30	46,118,000,000
November	2.69	0.06	1.35		1.41	1.28		12.25		769.20	51,545,000,000
Total	28.80	1.43	16.46	0.97	18.86				8.53		

Table No. 130 shows the area to be flooded, volume stored, and corresponding inches in depth on catchment area for successive elevations in the proposed Black River reservoir. In this table the elevation of water surface of 730 has been assumed as the base of the sections, the volume below that level being so small as to be negligible in the calculation of quantities. In Table No. 130 the area flooded in square miles, the volume stored, and the corresponding inches in depth on the tributary catchment area of 1,812.2 square miles are given for successive elevations of 1-foot levels from elevations 730 to 778.

Table No. 131 gives for Black River reservoir the storage and outgo from month to month, 1892 to 1898, inclusive.

SALMON RIVER RESERVOIR.

The object of this reservoir is to provide storage within reasonable distance of the main deep waterway so that in case of temporary stoppage of the main feeder to the north water could still be supplied to the canal. The ordinary elevation of water surface of Salmon River, a short distance above the proposed Dam No. 73, is approximately 897, the flats at the side being a little above 900. The water-surface elevation, as proposed for the reservoir, is 953. The total rise of water surface at or near the dam is, therefore, roundly, 56 feet. In addition to the main barrage there are three dikes, the first of them, Dam No. 74, cutting off a narrow, lateral valley near the lower end of the reservoir, while Dams Nos. 75 and 76, to the south of the village of Redfield, are in a broad, nearly level, somewhat swampy plain, where a comparatively small rise would throw Salmon River water over into the catchment area of Mad River, a tributary to West Branch of Fish Creek.

The small hamlet of Redfield is the only village within the area to be flooded. The lands to be taken include a considerable proportion of swamp and timber area, from which the valuable timber has been mostly cut. The balance of the area is not valuable, and this reservoir, as a whole, is considered to present favorable conditions for taking such an area. The details are sufficiently shown by the accompanying estimates. There is one cemetery to be removed at Redfield.

The volume and area, as determined by the surveys therefor, are as follows:

Elevation.	Area.	Volume.
	Sq. miles.	*Cubic feet.*
910	1.619	0.0
930	4.481	1,700,582,400.0
950	7.356	5,000,688,000.0
960	8.458	7,205,477,400.0

Elevation 910 was taken as the base of the sections, the volume below that level being neglected except that, in order to obtain a rounded quantity of 7,500,000,000 cubic feet for the volume at elevation 960, we may make the volume below 910 as 294,523,000 cubic feet, a quantity well within the volume shown by the surveys and maps. On this basis we have the following amended tabulation:

Elevation.	Area.	Volume.
	Sq. miles.	*Cubic feet.*
900	0.488	0.0
910	1.619	294,523,000.0
930	4.481	1,995.105,000.0
950	7.356	5,295,211.000.0
960	8.458	7,500,000,000.0

In Table No. 132 the area flooded, volume stored, and the corresponding inches in depth on the tributary catchment area of 190.5 square miles are given for successive elevations of 1-foot intervals from elevation 900 to 960.

In the Annual Report of the State Engineer and Surveyor of the State of New York for the fiscal year ending September 30, 1895, the author has shown, in his report on the Upper Hudson storage surveys, that reservoirs for storing water in the Adirondack region may be developed up to a storage of 13.5 inches on the tributary catchment area for a run-off like that of Hudson River. Inasmuch as the meteorological conditions on Black and Salmon rivers are the same as on Hudson, there is no reason why the argument made at length in the Hudson storage report may not apply here. Taking, then, the Hudson storage report as a part of this discussion, so far as necessary to cover the argument for reservoirs developing a storage of 13.5 inches on a catchment area subject to a run-off like that of the northern plateau of the State of New York, we may state the general problem in this way: Having given a reservoir of the area and volume shown in Table No. 132, and with a tributary catchment area of 190.5 square miles, it is required to find how much water can be reasonably expected to be collected from the watershed, stored in the reservoir, and drawn from it for canal use during a dry year, or during a series of such years. Inasmuch as the computation is the same for both cases, we will make it for the Salmon River reservoir only, except so far as it may be necessary to repeat the computation in discussing water supply to the main feeder line further on.

The water collected and stored in Salmon River reservoir during the entire year may be drawn from it in three ways, as follows:

(1) By evaporation from the surface of the reservoir.

(2) By supplying a certain fixed quantity to Salmon River below the dam during the entire year.

(3) By feeding the canal during the months of May, June, July, August, September, October, and November.

On the supposition that the reservoir will be nearly or quite empty at the end of the navigation season, or, in other words, that the largest possible amount will be fed to the canal, the general statement may be written in the following form:

(1) Outgo—(evaporation+quantity to stream+quantity to canal); and, by transposition of terms,

(2) Quantity to canal = outgo—(evaporation+quantity to stream).

In the above equation, if we can determine values for the terms of the second member, we can substitute them and solve for the first, which is the object of the investigation.

In previous pages we have discussed the run-off data of Hudson River, as determined by gaugings at Mechanicville. The catchment areas of Salmon River and upper Hudson being of the same general character as regards proportion of forests and annual rainfall, it is reasonable to estimate that the run-offs from the two streams will be substantially equal; hence the Hudson River data are, in the absence of extended gaugings of Salmon River, taken as practically applicable. These data have already been given in Tables Nos. 5, 6, and 7. Evaporation data, as given in Table No. 12, are considered as applying to Salmon River catchment area. In the following tabulation we have the evaporation for the months of a water year from December to November, inclusive, as computed in inches on the Salmon River catchment area for the actual reservoir area:

December	0.043	June	0.221
January	0.020	July	0.192
February	0.021	August	0.212
March	0.053	September	0.160
April	0.104	October	0.115
May	0.182	November	0.057

In designing a storage reservoir, it is the author's opinion that the stream is entitled to some water at all seasons of the year and computations of effective storage must be made with reference to allowing a definite quantity of water to go constantly to the stream. It is true that in some discussions of the deep waterways' water-supply question, it has been proposed to take absolutely all the water of the tributary catchment area, but this the author looks upon as a barbarism which the people of the State of New York ought not to permit. From this point of view it is necessary to decide on some mean flow below which the stream shall never be allowed to fall. This is done in the interests of water-power plants already located on the stream, fisheries, etc. In the Hudson River report, in the annual report of the State engineer and surveyor for 1895, the quantity fixed upon for storage in the upper Hudson catchment area is 0.5 inch per month. In cubic feet this amounts to 0.45 cubic foot per second per square mile for a month of thirty days. There is no reason why this quantity may not be used in the case of Salmon River reservoir. On Black River, where it is proposed to provide a flow of 2,200 feet per second to maintain water power, the conditions are different and the question of minimum allowance does not come into the discussion. With 0.45 cubic foot per second per square mile always flowing away from the regulated catchment area, we would have in the stream just below

Salmon River Dam, No. 47, about 87 to 88 cubic feet per second, which was approximately the observed low-water flow in the summer of 1898.

Having in the preceding discussion fixed our data, namely, run-off, evaporation, and allowance to stream, we may now combine these so as to obtain the first member of the foregoing equation (2), namely, quantity available for canal purposes, the computation taking the form of an approximation by trial. In making such a computation, the author has usually found the second trial to be sufficient.

Referring to Table No. 133, showing state of proposed Salmon River reservoir from month to month for the years 1892 to 1898, inclusive, we have, in column (2), the run-off of the stream, which equals inflow to reservoir. The outgoes, as shown by columns (3), (4), (5), and (6), are evaporation, amount to stream for maintenance of water power and fisheries, and amount to canal taken for the months from May to November, inclusive, at 300 cubic feet per second. The total outgo, as per column (6), is the same as columns (3), (4), and (5). In column (7) we have the difference between inflow, as per column (1), and total outgo, as per column (6), taken as an excess, this meaning that for any given month the quantity, as per column (7), was in excess of requirements for that month and went to increase the storage. In column (8) we have the deficiency—that is to say, in any month in which the total outgo, as per column (6), is greater than the total inflow, as per column (2), the storage would be drawn upon as per quantity in column (8). In column (9) we have the inches in depth of water over the entire catchment area in the reservoir at the end of each month, while column (10) shows the amount wasted from the reservoir in any given month.

Table No. 133 has been computed on the supposition that the reservoir was empty on the 1st of December, 1891. Taking the actual run-off figures of Hudson River, as per column (2), the computation is carried along in Table No. 133 for the water years 1892 to 1898, inclusive. The year of minimum run-off was 1895, when the total was 17.46 inches. At the end of November of that year there would have been left 5.19 inches in the reservoir. This was the lowest year of any in the period considered from 1892 to 1898, inclusive.

The following tabulation shows the state of the reservoir at the beginning and ending of each navigation season for the period covered by the table from December 1, 1891, to November 30, 1898, inclusive:

Date.	Inches in reservoir.	Date.	Inches in reservoir.
December 1, 1891	Empty.	December 1, 1895	5.19
May 1, 1892	[a] 13.50	May 1, 1896	[a] 13.50
December 1, 1892	11.07	December 1, 1896	8.12
May 1, 1893	[a] 13.50	May 1, 1897	[a] 13.50
December 1, 1893	5.62	December 1, 1897	11.94
May 1, 1894	[a] 13.50	May 1, 1898	[a] 13.50
December 1, 1894	6.61	December 1, 1898	10.88
May 1, 1895	[a] 13.50		

[a] Full.

The amounts wasted from Salmon River reservoir in the several water years from 1892 to 1898, inclusive, are as follows: In 1892, 9.93 inches; in 1893, 9.36 inches; in 1894, 2.93 inches; in 1895, 0.30 inch; in 1896, 4.30 inches; in 1897, 11.51 inches; in 1898, 13.64 inches.

TABLE No. 132.—*Showing area flowed, volume stored, and corresponding inches in depth on catchment area for successive elevations of the water surface in proposed Salmon River reservoir.*

Elevation of water surface. (1)	Area of water surface. (2)	Volume. (3)	Inches on catchment area of square miles. (4)
	Sq. miles.	*Cubic feet.*	
900	0.486	00,000,000	0.0000
901	0.600	29,452,300	0.0665
902	0.713	58,904,600	0.1330
903	0.825	88,356,900	0.1996
904	0.938	117,809,200	0.2661
905	1.053	147,261,500	0.3327
906	1.165	176,713,800	0.3992
907	1.279	206,166,100	0.4657
908	1.395	235,618,400	0.5322
909	1.510	265,070,700	0.5987
910	1.619	294,523,000	0.6655
911	1.758	379,552,100	0.8576
912	1.900	464,581,200	1.0497
913	2.044	549,610,300	1.2418
914	2.185	634,639,400	1.4339
915	2.326	719,668,500	1.6261
916	2.470	804,697,600	1.8182
917	2.615	889,726,700	2.0103
918	2.756	974,755,800	2.2024
919	2.903	1,059,784,900	2.3946
920	3.050	1,144,814,000	2.5867
921	3.192	1,229,843,100	2.7788
922	3.333	1,314,872,200	2.9709
923	3.475	1,399,901,300	3.1630
924	3.618	1,484,930,400	3.3551
925	3.760	1,569,959,500	3.5473
926	3.902	1,654,988,600	3.7394
927	4.045	1,740,017,700	3.9315
928	4.188	1,825,046,800	4.1237
929	4.331	1,910,075,900	4.3159
930	4.481	1,995,105,000	4.5080
931	4.623	2,160,110,300	4.8808
932	4.770	2,325,115,600	5.2536
933	4.913	2,490,120,900	5.6264
934	5.060	2,655,126,200	5.9993
935	5.202	2,820,131,500	6.3722
936	5.345	2,985,136,800	6.7450
937	5.490	3,150,142,100	7.1178
938	5.624	3,315,147,400	7.4906
939	5.780	3,480,152,700	7.8634
940	5.920	3,645,158,000	8.2363
941	6.060	3,810,163,300	8.6091
942	6.210	3,975,168,600	8.9819
943	6.350	4,140,173,900	9.3548
944	6.498	4,305,179,200	9.7276
945	6.638	4,470,184,500	10.1005
946	6.780	4,635,189,800	10.4733
947	6.925	4,800,195,100	10.8462
948	7.068	4,965,200,400	11.2190
949	7.210	5,130,205,700	11.5918
950	7.356	5,295,211,000	11.9646
951	7.460	5,515,689,900	12.4628
952	7.575	5,736,168,800	12.9610
953	7.685	5,956,647,700	13.4591
954	7.800	6,177,126,600	13.9573
955	7.907	6,397,605,500	14.4555
956	8.020	6,618,084,400	14.9537
957	8.130	6,838,563,300	15.4519
958	8.237	7,059,042,200	15.9501
959	8.349	7,279,521,100	16.4483
960	8.458	7,500,000,000	16.9464

TABLE NO. 133.—*Showing state of proposed Salmon River reservoir from month to month, 1892 to 1898, inclusive, with draft therefrom as required by Table No. 135, from May to November, inclusive.*

[In inches on tributary catchment area of 190.5 square miles.]

Month.	Run-off. Inflow to reservoir.	Outgo from reservoir.				Excess.	Deficiency.	In reservoir at end of month.	Wasted from reservoir.
		Evaporation.	To stream 0.50 inch per month.	To canal as required, column (3), table 135.	Total outgo.				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1892.									
December	2.27	0.04	0.50		0.54	1.73		1.73	
January	4.83	0.02	0.50		0.52	4.31		6.04	
February	2.22	0.02	0.50		0.52	1.70		7.74	
March	2.80	0.05	0.50		0.55	2.25		9.99	
April	5.35	0.10	0.50		0.60	4.75		13.50	1.24
May	5.03	0.18	0.50		0.68	4.35		13.50	4.35
June	3.08	0.22	0.50		0.72	2.36		13.50	2.36
July	2.38	0.18	0.50		0.68	1.70		13.50	1.70
August	1.41	0.19	0.50	0.44	1.13	0.28		13.50	0.28
September	1.10	0.15	0.50	1.76	2.41		1.31	12.19	
October	0.72	0.10	0.50	1.81	2.41		1.69	10.50	
November	1.89	0.04	0.50	0.78	1.32	0.57		11.07	
Total	33.08	1.29	6.00	4.79	12.08	24.00	3.00		9.93
1893.									
December	1.03	0.04	0.50		0.54	0.49		11.56	
January	0.82	0.02	0.50		0.52	0.30		11.86	
February	1.09	0.02	0.50		0.52	0.57		12.43	
March	2.11	0.05	0.50		0.55	1.56		13.50	0.49
April	4.44	0.10	0.50		0.60	3.84		15.50	3.84
May	5.71	0.18	0.50		0.68	5.03		13.50	5.03
June	1.19	0.22	0.50	1.76	2.48		1.29	12.21	
July	0.65	0.18	0.50	1.81	2.49		1.84	10.37	
August	1.28	0.19	0.50	1.81	2.50		1.22	9.15	
September	1.70	0.15	0.50	1.76	2.41		0.71	8.44	
October	0.99	0.10	0.50	1.81	2.41		1.42	7.02	
November	0.90	0.04	0.50	1.76	2.30		1.40	5.62	
Total	21.91	1.29	6.00	10.71	18.00	11.79	7.88		9.36
1894.									
December	1.85	0.04	0.50		0.54	1.31		6.93	
January	1.73	0.02	0.50		0.52	1.21		8.14	
February	1.12	0.02	0.50		0.52	0.60		8.74	
March	3.78	0.05	0.50		0.55	3.23		11.97	
April	2.76	0.10	0.50		0.60	2.16		13.50	0.63
May	1.94	0.18	0.50		0.68	1.26		13.50	1.26
June	1.76	0.22	0.50		0.72	1.04		13.50	1.04
July	0.81	0.18	0.50	1.81	2.49		1.68	11.82	
August	0.63	0.19	0.50	1.81	2.50		1.87	9.95	
September	0.47	0.15	0.50	1.76	2.41		1.94	8.01	
October	0.94	0.10	0.50	1.81	2.41		1.47	6.54	
November	1.58	0.04	0.50	0.97	1.51	0.07		6.61	
Total	19.37	1.29	6.00	8.16	15.45	10.88	6.96		2.93
1895.									
December	1.12	0.04	0.50		0.54	0.58		7.19	
January	0.99	0.02	0.50		0.52	0.47		7.66	
February	0.82	0.02	0.50		0.52	0.30		7.96	
March	1.08	0.05	0.50		0.55	0.53		8.49	
April	5.91	0.10	0.50		0.60	5.31		13.50	0.30
May	1.76	0.18	0.50	1.81	2.49		0.73	12.77	
June	0.70	0.22	0.50	1.76	2.48		1.78	10.99	
July	0.66	0.18	0.50	1.81	2.49		1.83	9.16	
August	1.00	0.19	0.50	1.81	2.50		1.50	7.66	
September	0.65	0.15	0.50	1.76	2.41		1.76	5.90	
October	0.69	0.10	0.50	1.81	2.41		1.72	4.18	
November	2.08	0.04	0.50	0.53	1.07	1.01		5.19	
Total	17.46	1.29	6.00	11.29	18.58	8.20	9.32		0.30
1896.									
December	2.79	0.04	0.50		0.54	2.25		7.44	
January	1.74	0.02	0.50		0.52	1.22		8.66	
February	1.12	0.02	0.50		0.52	0.60		9.26	
March	3.49	0.05	0.50		0.55	2.94		12.20	

Table No. 133.—*Showing state of proposed Salmon River Reservoir from month to month, 1892 to 1898, inclusive, with draft therefrom as required by Table No. 135, from May to November, inclusive*—Continued.

Month.	Run-off. Inflow to reservoir.	Outgo from reservoir.				Excess.	Deficiency.	In reservoir at end of month.	Wasted from reservoir.
		Evaporation.	To stream 0.50 inch per month.	To canal as required, column (3), table 135.	Total outgo.				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1896.									
April	6.20	0.10	0.50	....	0.60	5.60	....	13.50	4.30
May	1.18	0.18	0.50	1.81	2.49	....	1.31	12.19	....
June	1.18	0.22	0.50	1.76	2.48	....	1.30	10.89	....
July	0.72	0.18	0.50	1.81	2.49	....	1.77	9.12	....
August	0.63	0.19	0.50	1.81	2.50	....	1.87	7.25	....
September	0.71	0.15	0.50	1.76	2.41	....	1.70	5.55	....
October	1.05	0.10	0.50	0.16	0.76	0.29	....	5.84	....
November	2.82	0.04	0.50	....	0.54	2.28	....	8.12	....
Total	23.63	1.29	6.00	9.11	16.40	15.18	7.95	....	4.30
1897.									
December	1.77	0.04	0.50	....	0.54	1.23	....	9.35	....
January	1.03	0.02	0.50	....	0.52	0.51	....	9.86	....
February	0.90	0.02	0.50	....	0.52	0.38	....	10.24	....
March	3.13	0.05	0.50	....	0.55	2.58	....	12.82	....
April	4.73	0.10	0.50	....	0.60	4.13	....	13.50	3.45
May	3.04	0.18	0.50	....	0.68	2.36	....	13.50	2.36
June	2.94	0.22	0.50	....	0.72	2.22	....	13.50	2.22
July	2.74	0.18	0.50	....	0.68	2.06	....	13.50	2.06
August	2.11	0.19	0.50	....	0.69	1.42	....	13.50	1.42
September	0.68	0.15	0.50	1.76	2.41	....	1.73	11.77	....
October	0.65	0.10	0.50	1.81	2.41	....	1.76	10.01	....
November	2.45	0.04	0.50	....	0.54	1.93	....	11.94	....
Total	26.19	1.29	6.00	3.57	10.86	18.82	3.49	....	11.51
1898.									
December	3.67	0.04	0.50	....	0.54	3.13	....	13.50	1.57
January	1.97	0.02	0.50	....	0.52	1.45	....	13.50	1.45
February	1.56	0.02	0.50	....	0.52	1.04	....	13.50	1.04
March	5.18	0.05	0.50	....	0.55	4.63	....	13.50	4.63
April	3.40	0.10	0.50	....	0.60	2.80	....	13.50	2.80
May	2.83	0.18	0.50	....	0.68	2.15	....	13.50	2.15
June	1.30	0.22	0.50	1.72	2.44	....	1.14	12.36	....
July	0.64	0.18	0.50	1.81	2.49	....	1.85	10.51	....
August	1.30	0.19	0.50	1.81	2.50	....	1.20	9.31	....
September	0.96	0.15	0.50	1.76	2.41	....	1.45	7.86	....
October	2.02	0.10	0.50	0.17	0.77	1.25	....	9.11	....
November	2.29	1.04	0.50	....	0.54	1.75	....	10.86	....
Total	27.12	1.29	6.00	7.27	14.56	18.20	5.64	....	13.64

TABLE NO. 133 A.—*Showing state of proposed Salmon River Reservoir from month to month, 1892 to 1898, inclusive, with draft therefrom as required by Table No. 134, from May to November, inclusive.*

[In inches on tributary catchment area of 190.5 square miles.]

		Outgo from reservoir.							
Month.	Run-off. Inflow to reservoir.	Evaporation.	To stream 0.50 inch per month.	To canal as required, column (5), Table 134.	Total outgo.	Excess.	Deficiency.	In reservoir at end of month.	Wasted from reservoir.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1892.									
December	2.27	0.04	0.50	....	0.54	1.73	....	1.73	....
January	4.83	0.02	0.50	....	0.52	4.31	....	6.04	....
February	2.22	0.02	0.50	....	0.52	1.70	....	7.74	....
March	2.80	0.05	0.50	....	0.55	1.25	....	8.99	....
April	5.35	0.10	0.50	....	0.60	4.75	....	13.50	0.24
May	5.03	0.18	0.50	....	0.68	4.35	....	13.50	4.35
June	3.08	0.22	0.50	....	0.72	2.36	....	13.50	2.36
July	2.38	0.18	0.50	....	0.68	1.70	....	13.50	1.70
August	1.41	0.19	0.50	0.63	1.32	0.09	....	13.50	0.09
September	1.10	0.15	0.50	1.76	2.41	....	1.31	12.19	....
October	0.72	0.10	0.50	1.81	2.41	....	0.69	11.50	....
November	1.89	0.04	0.50	1.73	2.27	....	0.38	11.12	....
Total	33.08	1.29	6.00	5.93	13.22	22.24	2.38	....	8.74
1893.									
December	1.03	0.04	0.50	....	0.54	0.49	....	11.61	....
January	0.82	0.02	0.50	....	0.52	0.30	....	11.91	....
February	1.09	0.02	0.50	....	0.52	0.57	....	12.48	....
March	2.11	0.05	0.50	....	0.55	1.56	....	13.50	0.54
April	4.44	0.10	0.50	....	0.60	3.84	....	13.50	3.84
May	5.71	0.18	0.50	....	0.68	5.03	....	13.50	5.03
June	1.19	0.22	0.50	1.76	2.48	....	1.29	11.21	....
July	0.65	0.18	0.50	1.81	2.49	....	1.84	9.37	....
August	1.28	0.19	0.50	1.81	2.50	....	1.22	8.15	....
September	1.70	0.15	0.50	1.76	2.41	....	0.71	7.44	....
October	0.99	0.10	0.50	1.81	2.41	....	1.42	6.02	....
November	0.90	0.04	0.50	1.76	2.30	....	1.40	4.62	....
Total	21.91	1.29	6.00	10.71	18.00	11.79	7.88	....	9.41
1894.									
December	1.85	0.04	0.50	....	0.54	1.31	....	5.93	....
January	1.73	0.02	0.50	....	0.52	1.21	....	7.14	....
February	1.12	0.02	0.50	....	0.52	0.60	....	7.74	....
March	3.78	0.05	0.50	....	0.55	3.23	....	10.97	....
April	2.76	0.10	0.50	....	0.60	2.16	....	13.13	....
May	1.94	0.18	0.50	....	0.68	1.26	....	13.50	0.89
June	1.76	0.22	0.50	0.22	0.94	0.82	....	13.50	0.82
July	0.81	0.18	0.50	1.81	2.49	....	1.68	11.82	....
August	0.63	0.19	0.50	1.81	2.50	....	1.87	9.95	....
September	0.47	0.15	0.50	1.76	2.41	....	1.94	8.01	....
October	0.94	0.10	0.50	1.81	2.41	....	1.47	6.54	....
November	1.58	0.04	0.50	1.71	2.25	....	0.67	5.87	....
Total	19.37	1.29	6.00	9.12	16.41	10.59	7.63	....	1.71
1895.									
December	1.12	0.04	0.50	....	0.54	0.58	....	6.45	....
January	0.99	0.02	0.50	....	0.52	0.47	....	6.92	....
February	0.82	0.02	0.50	....	0.52	0.30	....	7.22	....
March	1.08	0.05	0.50	....	0.55	0.53	....	7.75	....
April	5.91	0.10	0.50	....	0.60	5.31	....	13.06	....
May	1.76	0.18	0.50	1.81	2.49	....	0.73	12.33	....
June	0.70	0.22	0.50	1.76	2.48	....	1.78	10.55	....
July	0.66	0.18	0.50	1.81	2.49	....	1.83	8.72	....
August	1.00	0.19	0.50	1.81	2.50	....	1.50	7.22	....
September	0.65	0.15	0.50	1.76	2.41	....	1.76	5.46	....
October	0.69	0.10	0.50	1.81	2.41	....	1.72	3.74	....
November	2.08	0.04	0.50	1.53	2.07	0.01	....	3.75	....
Total	17.46	1.29	6.00	12.29	19.58	7.20	9.32	....	....
1896.									
December	2.79	0.04	0.50	....	0.54	2.25	....	6.00	....
January	1.74	0.02	0.50	....	0.52	1.22	....	7.22	....
February	1.12	0.02	0.50	....	0.52	0.60	....	7.82	....

Table No. 133 A.—*Showing state of proposed Salmon River Reservoir from month to month, 1892 to 1898, inclusive, with draft therefrom as required by Table No. 134, from May to November, inclusive*—Continued.

Month.	Run-off. Inflow to reservoir.	Outgo from reservoir.				Excess.	Deficiency.	In reservoir at end of month.	Wasted from reservoir.
		Evaporation.	To stream 0.50 inch per month.	To canal as required, column (5), Table 134.	Total outgo.				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1896.									
March	3.49	0.05	0.50	....	0.55	2.94	....	10.76	....
April	6.20	0.10	0.50	....	0.60	5.60	....	13.50	2.86
May	1.18	0.18	0.50	1.81	2.49	....	1.31	12.19	....
June	1.18	0.22	0.50	1.76	2.48	....	1.30	10.89	....
July	0.72	0.18	0.50	1.81	2.49	....	1.77	9.12	....
August	0.63	0.19	0.50	1.81	2.50	....	1.87	7.25	....
September	0.71	0.15	0.50	1.76	2.41	....	1.70	5.55	....
October	1.05	0.10	0.50	....	0.60	0.45	....	6.00	....
November	2.82	0.04	0.50	....	0.54	2.28	....	8.28	....
Total	23.63	1.29	6.00	8.95	16.24	15.34	7.95	....	2.86
1897.									
December	1.77	0.04	0.50	....	0.54	1.23	....	9.51	....
January	1.03	0.02	0.50	....	0.52	0.51	....	10.02	....
February	0.90	0.02	0.50	....	0.52	0.38	....	10.40	....
March	3.13	0.05	0.50	....	0.55	2.58	....	12.98	....
April	4.73	0.10	0.50	....	0.60	4.13	....	13.50	3.61
May	3.04	0.18	0.50	....	0.68	2.36	....	13.50	2.36
June	2.94	0.22	0.50	....	0.72	2.22	....	13.50	2.22
July	2.74	0.18	0.50	....	0.68	2.06	....	13.50	2.06
August	2.11	0.19	0.50	....	0.69	1.42	....	13.50	1.42
September	0.68	0.15	0.50	1.76	2.41	....	1.73	11.77	....
October	0.65	0.10	0.50	1.81	2.41	....	1.76	10.01	....
November	2.47	0.04	0.50	0.78	1.32	1.15	....	11.16	....
Total	28.19	1.29	6.00	4.35	11.64	18.04	3.49	....	11.67
1898.									
December	3.67	0.04	0.50	....	0.54	3.13	....	13.50	0.79
January	1.97	0.02	0.50	....	0.52	1.45	....	13.50	1.45
February	1.56	0.02	0.50	....	0.52	1.04	....	13.50	1.04
March	5.18	0.05	0.50	....	0.55	4.63	....	13.50	4.63
April	3.40	0.10	0.50	....	0.60	2.80	....	13.50	2.80
May	2.83	0.18	0.50	....	0.68	2.15	....	13.50	2.15
June	1.30	0.22	0.50	1.76	2.48	....	1.18	12.32	....
July	0.64	0.18	0.50	1.81	2.49	....	1.85	10.47	....
August	1.30	0.19	0.50	1.81	2.50	....	1.20	9.27	....
September	0.96	0.15	0.50	1.76	2.41	....	1.45	7.82	....
October	2.02	0.10	0.50	0.85	1.45	0.57	....	8.39	....
November	2.29	0.04	0.50	....	0.54	1.75	....	10.14	....
Total	27.12	1.29	6.00	7.99	15.28	17.52	5.68	....	12.86

It is evident from the foregoing tabulations that Salmon River reservoir is capable of yielding, in an emergency, considerably more water in the canal than the tabulated quantities. The quantity still in the reservoir at the end of the dry year 1895 is 5.19 inches on the catchment area, or about 2,250,000,000 cubic feet.

DISCUSSION OF THE PROPOSED BLACK RIVER FEEDER.

We may now take up a discussion of the feeder line as surveyed from Carthage to near Fort Bull, via Rutland Hollow, Sandy Creek, and West Branch of Fish Creek, etc., as shown in general outline on plate 93. When the surveys for this feeder were begun, the latter part of August, 1898, the datum assumed was crest of State dam at Carthage, taken at elevation 723.53. At that time it was considered that this elevation was very nearly correct, the State engineer and surveyor of the State of New York having a few years previously run a line of levels from Rome to Carthage and correcting previous elevation of Carthage dam by 2.13 feet. It appeared, however, when the feeder levels were finally connected with those of the main ship canal near New London, that there was a difference of 3.79 feet. The following are the determined elevations at bench mark No. 45 of main ship-canal survey:

	Feet.
Elevation of bench at New London of main ship-canal survey, as per Mr. Himes	409.22
Elevation of this bench as per feeder survey	405.43
Difference	3.79

Hence it appears that the feeder-line levels are lower than the main ship-canal levels by the foregoing amount, which fact should be taken into account in comparing the two surveys where they join together near Fort Bull.

The feeder-line levels have all been checked from Carthage to Fort Bull, and, aside from the initial difference in datum referred to in the foregoing, are believed to be right.

Taking into account the foregoing difference of levels of 3.79 feet, the elevation of Oswego-Mohawk summit level becomes 411.21 feet, instead of 415, as per main ship-canal survey. All elevations following are corrected to conform to main ship-canal survey.

Station 0 of the feeder line begins at the west bank of Black River, near the west end of the State dam. The canal proper, however, is extended up the river from this point about 1,000 feet to the main barrage across Black River. Dam No. 2, which extends from opposite station 0 of the feeder line to the main barrage, separates this portion of the canal from the main pond above the State dam. Dam No. 2 is rendered necessary, not only because it has been deemed desirable to make the water surface of the canal 6 feet above crest of State dam, or at elevation 733.3, but further in order to absolutely separate canal water from compensation water to the river, the arrangements of the main barrage being such as to permit of discharging the proper quantity to the canal absolutely without reference to the quantity to the river, there being separate sluices for each supply. By carrying out this arrangement a prolific source of dispute between mill owners on Black River and canal authorities will be eliminated.

In the preliminary studies it was assumed that this feeder would, at times, be required to deliver from 1,800 to 2,000 cubic feet per second, and that the allowable maximum velocity in firm earth sections might be taken at from 2 to about 2.5 linear feet per second. This velocity, it was considered, would be swift enough to prevent the growth of weeds or the deposition of silt, and at the same time would not seriously erode the heavy soils with which we have mostly to deal on this work. A mean velocity of about 1.9 to 2.5 linear feet per second for the assumed cross sections gives, roundly, a grade of 1 foot per mile, which is the grade generally used, except in rock sections, where higher grades, with the consequent higher velocities, are permissible. The limit and extent of such may be seen by reference to the data on the profile and to the tabulations following. As the study proceeded and estimates of quantity of water to be taken from Black River in different years were perfected, it was found that the quantity would not only be somewhat smaller than originally assumed, but that in years of maximum, or nearly maximum run-off, the quantity to be taken would be quite small. Thus, from Table No. 134, which gives in column (9) the quantity of water to be taken from Black River in each month for the water years 1892 to 1898, inclusive, it appears that with the large run-offs of the years 1892 and 1897 it would only be necessary to take water from Black River during two months of those years, namely, September and October in 1892, and the same months in 1897. In 1898 water would be taken during the three months, July, August, and September, while in a dry year, like 1895, water would require to be taken from May to October, inclusive. The establishing of this fact led to some new views as to the coefficient of rugosity properly applicable to this feeder. The original computations were on the basis of a value of n of 0.025 in the Kutter formula, but when it is learned that the feeder, in wet years, may be used only two months and will be, consequently, subject to rank vegetable growth, it was at once apparent that the value of n of 0.025 would be too small. Taking into account such sources of retardation, as well as the fact that a channel of this character, used intermittently, will not be as well taken care of as though in constant service, it has seemed safer to mostly use a value of n of 0.035, except in narrow, deep rock cuts, where the depth of water has been made from 18 to 20 feet, with consequent increased value of r, in which cases a value of n of 0.031 has been used. This view is further enforced by considering that the feeder channel will be subject at all seasons to inflow of flood waters from many side hill streams, which will bring down detritus to form bars and obstructions generally. The cross currents and eddies produced by such obstructions will tend to reduce the mean velocity. It is proposed to channel the sides of the rock cuts and, except for the fact that the nearly vertical side walls may be expected to slough off, causing obstructions in the bottom, the value of n for such sections could be taken somewhat lower. Again, there are a few places where the earth slopes may possibly show a tendency to slide and which should be protected by growths of willows, which, when growing along the margins and lopping over into the water, will further tend to retard flow. These several retarding causes appear to indicate the propriety of using a maximum value of n of about 0.035. On the other hand, when the channel is new and the bottom and sides in good order, we may expect flows equivalent to a value of n of about 0.025 to 0.030. Depending, then, on the condition of the channel, values of n may be expected to vary from 0.025 to 0.035. It is fully recognized, in short, that there is no such thing as positively defining the flow through a channel of this character, subject to the mutations of extreme flood flow at one time and heavy vegetable growths at another. It is considered that the proper treatment is to design the channel large enough to carry the maximum quantity under the most adverse conditions. It is from this point of view that the sections have been provisionally adopted as shown.

In regard to the cross sections, it may be remarked that the feeder has been nominally designed to carry from Carthage to Sandy Creek (Dam No. 8) 1,600 cubic feet per second. From Dam No. 8 (station 1389+50) to the head waters of Fish Creek at Kasoag the channel is designed to carry 1,100 cubic feet per second, and from Fish Creek (station 4297+70) to main ship canal near Fort Bull the cross sections have been designed to carry 1,200 cubic feet per second. Quantities on these several sections, however, are somewhat relative. Throughout its whole extent the feeder is further designed with reference to carrying large flood flows, so that by slight forcing of the smaller sections an additional amount of water could be passed through, if necessary, the figures as given in the foregoing representing merely the assumed capacities when little or no water is passing except that required for canal supply. The reasons for reducing the section materially below Dam No. 8 on Sandy Creek will be given further on.

As shown in Flood Flows of Streams in the State of New York, the run-offs from the tributary streams, especially at the upper end of Black River feeder, are very large. As there seems to be no way to avoid taking these streams directly into the feeder discharging flood waters at convenient points, it became imperative that the channel be made of liberal dimensions in order to prevent catastrophies with extreme flood flows. These several considerations are stated as further reasons for assuming a rather high value of n. As to the values of n used for each section, refer to data given with tabulation of cross sections following.

As shown on the profile, plate 140, from station 0 to station 18 the feeder is made 81 feet wide and 10 feet deep, with substantial retaining walls at each side. From station 18 to station 107 + 20 the channel is an open cut with bottom in rock for the whole distance. From station 120 to station 176 the work is in tunnel with a cross section of 20 feet by 17.5 feet. For this section we have $n = 0.031$ and $v = 4.6$ linear feet per second. From station 176 to station 531 the feeder is an open cut with the bottom entirely in rock, except for a few hundred feet at about station 310, and also for a few hundred feet at about station 382. At station 530 the feeder enters the head of Rutland Hollow, occupying a natural valley to station 670, at which point the bottom of the valley is at an elevation of 675. Dam No. 6 at this point raises the water to the elevation 716.5, thus creating an extensive pond in Rutland Hollow. From station 672 + 10 to station 927 + 30 the line crosses by a deep rock cut through the divide, separating Rutland Hollow from West Branch of Sandy Creek. The channel is in rock throughout this entire section, except for about 1,200 feet at Dam No. 7 (station 770). The cross sections, values of *n*, mean velocity, slope, etc., are given on profile and in the table following. From about station 872 + 70 to 927 + 30 the artificial channel is, in effect, a mere drainage ditch for the purpose of draining the rock cut when necessary for cleaning or repairs. On the general question of drainage it may be remarked that the whole feeder has been designed with drainage ditches, when necessary, in the bottom, in order to drain the work if required. Throughout the whole section from station 872 + 70 to Sandy Creek (Dam No. 8) it is proposed to take a right of way wide enough to cover all contingencies, allowing the water to pursue its own course through the valley, this being considered more economical than to attempt to rectify the meandering creek channel.

The main dam on Sandy Creek (No. 8), opposite station 1365 + 90, is to be of earth, 20 feet wide at the top, with 2.5 to 1 slope on the upstream side and 2 to 1 slope on the downstream side, paved on the upstream slope and sodded on the downstream. Ordinarily the earth dams have been made 15 feet wide on top, but Dam No. 8 and a few others have been increased to 20 feet in order to accommodate new wagon roads crossing the tops. On the north side of the valley the Trenton limestone appears in a ledge at the surface of the ground, but dropping off nearly vertically. To the south of this ledge of Trenton limestone, from 25 to 30 feet below the creek bottom, a shale rock is found. The foundation of Dam No. 8 is cut well into the shale.

A substantial core wall of masonry is carried up from the shale rock foundation to within 3 feet of the extreme top of the dam. The natural catchment area of Sandy Creek above Dam No. 8 is 107 square miles, from which there may be expected flood flows of about 100 cubic feet per second per square mile, or a total of, perhaps, 10,000 cubic feet per second. To accommodate such flood flows the spillway has been made of liberal length and provided with an inexpensive form of movable crest, to be operated by mechanical appliances driven by a turbine water wheel. This movable crest, when in place, is at an elevation of 6 inches above the water surface of the pond, which is taken at elevation 659.7.

While on the subject of dams, it may be remarked that, generally speaking, the dams have been designed with the extreme tops 6 feet above the ordinary flow line of the feeder, although in a few cases they have been made 10 feet. Earth dams have all been designed with 2.5 to 1 paved slopes on the water side and 2 to 1 sodded slopes on the downstream side, and with 12 inches of lining under the paving and 12 inches of soiling under the sod. The more important earth dams have masonry core walls, which, generally speaking, have been carried down and well into the rock. In a few cases, however, foundations for core walls have been made on hardpan or firm clay.

The main barrage on Black River (Dam No. 1); the two dams on Salmon River (Nos. 53 and 73); Dam No. 9, on South Branch Sandy Creek; Dam No. 11, on Deer Creek; Dam No. 12, on Loraine Brook, and Dam No. 60, on West Branch of Fish Creek, are designed to be substantial masonry constructions, cross sections for all of which are given in the manuscript sheets of cross section. A considerable number of the dams are provided with spillways with paved or concrete wasteways, etc., as is deemed necessary for proper discharge of flood waters.

From station 1389 + 50, where the feeder leaves the Sandy Creek pond (Dam No. 8), to station 2904 + 30, at the south end of the lower Kasoag pond, where the feeder enters the head waters of the West Branch of Fish Creek, the grade, except through the several ponds, is substantially 1 foot per mile. On this section there are 33 ponds, all of which, with the exception of 3, are formed by throwing dams across valleys. The exceptions are the upper, middle, and lower Kasoag ponds, which are natural, and which have been taken advantage of as part of the line of the feeder. There are also two vertical drops—one at Dam No. 57, where the feeder enters the upper Kasoag pond, and Dam No. 58, where it leaves the lower Kasoag pond. There are also a number of places where it has been deemed desirable to make dam constructions at points where the water surface of feeder is either at or a little above the natural surface. Moreover, there are a number of places where the assumed water surface of feeder is very near the natural surface, but where it has been considered not worth while to make special constructions. At all such places it is proposed to form an embankment with the spoil from the excavation, carrying the same to heights of from 5 to 10 feet above the natural surface, as may be necessary to insure safety during flood flow. At points of this character where it has been deemed necessary to make special constructions the natural surface slopes rapidly away from the feeder line, whereas at points where special constructions are considered unnecessary, but simple embankments must nevertheless be constructed for protection against flood flows, the natural surface is flat on the lower side of the feeder.

On the section of feeder from Sandy Creek to Kasoag, for a considerable portion of the way the excavation is in shale rock, sandstone, and hardpan. It is considered that for the most of this section the material will retain water. In the vicinity of Salmon River, however, from about station 2520 to station 2635 the excavation is in gravel, which was found on test to not be watertight. This section of the canal will require careful puddling and probably riprap to hold the puddle in place. The material for puddle may be obtained within a reasonable distance.

The crossing of Salmon River is made by Dam No. 53, provision being made to drain this dam when necessary for cleaning or repairs. To the south of Salmon River the line passes from about station 2710 to station 2780, through a swamp now subject to more or less constant flooding from Beaver Dam Brook. The material of this swamp is soft muck which, when seen in sample, will apparently stand only at exceedingly flat slopes, but in actual fact, however, along the Beaver Dam Brook, where it is interlaced with roots, it stands at about 1 to 1 slope. It is not considered, therefore, that there will be any difficulty in making the feeder excavation through this section. In order to maintain the water level of the swamp it is proposed to construct a small timber dam at a narrow pass 2,000 feet west of station 2735.

The original design contemplated a series of dikes, beginning at about station 2530 and extending to opposite station 2575 and including Dams Nos. 47–52, inclusive, and making a pond extending from station 2531+50 to 2830+20. The surveys had apparently indicated a series of glacial ridges on this section, presumably with hardpan not far below the surface. The borings, however, showed that instead of being glacial ridges they were sand ridges, formed by the action of flowing and eddying water, several of them showing open, porous sand to considerable depths, while at Dam No. 50, the closure of the outflowing stream, the borings developed quicksand to considerable depth. These several objectionable features seem to render the dikes on this section impracticable. The pond was accordingly abandoned and a new line located along the side hill to the northeast, the new line being the section already described as lying in gravel and requiring puddle with overlying riprap.

At station 2904+30, at the lower end of Kasoag ponds, there is a natural dike 15 feet in height, which now retains the water of those ponds. The vertical drop from the lower pond to the channel of Fish Creek below has been located at near the east end of this dike. The balance of the dike is to be strengthened with waste material from the spillway excavation.

Below Kasoag ponds the feeder enters West Branch of Fish Creek. For several miles the channel is narrow and incapable of carrying the ordinary feeder flows in addition to flood flows. The areas at the side are level and in places swampy for considerable distances. At Williamstown there are two dams (stations 3108 and 3132+50) creating small water powers. Below Williamstown the channel is still narrow and tortuous, with occasional swamp areas at the sides. Above West Camden the creek flows through Gifford's Lake, about 1 mile in length, the West Camden dam (station 3420) being at the lower end of said lake. Below West Camden the cross section of the stream increases in size, becoming large enough to take the ordinary feeder flows without overflow, except at time of flood. Just above the village of Camden, at De Lapp's dam (station 3666), it is proposed to make a cut-off flood-water channel through which the major portion of the flow due to the feeder can be taken out of Fish Creek and delivered into Mad River, a short distance to the east, and so carried around the village of Camden without danger of overflow, finally again flowing into Fish Creek, the situation being complicated there by three water-power dams in the heart of the village. There are also two water-power dams on Mad River below the point where the flood-water channel would enter that stream, but it is considered that the necessary arrangements for safely passing flood flows can be made more cheaply on Mad River than in the present channel of West Branch of Fish Creek through the village of Camden. Below Camden and between that point and Dam No. 54 (station 4302+70), where the lower section of the feeder begins, the channel is deep and will carry the feeder water in addition to the flood flows without serious overflow. Throughout the whole extent of West Branch of Fish Creek, where the feeder water is likely to cause overflow, the estimates of land damages have been made liberal enough to cover the purchase of such a broad strip as to insure Government ownership of all lands which can by any possibility be affected. Hence it has appeared unnecessary to expend anything in rectification of channel. It is proposed, however, to, so far as necessary, purchase the existing water powers on West Branch of Fish Creek on the ground that the present power dams are mostly temporary constructions which, while sufficient to stand flood flows for a few days each year, are insufficient when a constant addition of, say, 1,200 cubic feet per second is made to the stream. The effect of not purchasing them would be to leave the onus of maintenance upon the ship canal management. The author's view is that the proper procedure is to compensate the owners for the existing structures, leaving them free to build new structures adequate to the changed conditions, but without any claim for damages on account of the increased flow, new constructions to be made, so far as necessary, for control of feeder water, subject to approval of ship canal authorities. A series of cross sections of the Fish Creek channel are shown on the maps. The notes of these sections, together with outline plans and profiles of the several dams on West Branch, may be found with the notes and miscellaneous papers turned in to your Board. It has not seemed worth while to plot out for publication these cross-section plans and profiles.

Dam No. 54, about opposite station 4302+70, is a mere diversion weir for the purpose of turning the flow in the channel of West Branch of Fish Creek into the feeder channel. The relation of Dam No. 54 to feeder is, as shown on map, with reference to utilization of basin above Dam No. 54 for catching silt. Arrangements are proposed at this dam for sluicing out the silt when it has nearly filled the pond.

At station 4435 we have Dam No. 57 crossing East Branch of Fish Creek, which is designed to be mainly of earth with masonry spillway with substantial wing walls and paved wasteway channel leading from spillway to main channel of creek below Dam No. 57 as shown. The general design of the several paved wasteway channels indicated on the maps is to make, in every case, a cut-off wall, which, in the present case, is the main spillway wall, carrying the same down well onto or into rock or hard, stable material, as the case may be. The paving will be mostly made of large bowlders, set in concrete, when necessary for permanent construction several feet in thickness. The points where such spillways are located are indicated on the maps, rendering detailed reference to each unnecessary. The general design on which the estimates have been prepared is the same for all. Retaining walls are proposed for confining these wasteway channels, so far as necessary. From Dams Nos. 58 to 63, inclusive, the foundations are on clay at some places, as shown by the detailed profiles and cross sections submitted, to considerable depths. The borings indicate that these clays are water-tight and while careful construction will be imperative, it is believed that there is no difficulty about making this section of the feeder safe.

At station 4577+40 the feeder leaves the artificial pond created by Dam No. 63, passing into what is locally known as the "sand plains," and continues substantially therein to between Dams Nos. 65 and 66, where it passes into the broad valley of Canada and Wood creeks.

A boring was made near station 4593+40, where main north and south highway from Humaston Station to New London crosses feeder line. The boring notes show that from 0 to 40 feet the material was quicksand or very fine sand, except that at 36 feet down a layer of clay 6 inches in thickness was passed through. Water appeared in the bore hole at depth of 12 feet. The depth of cutting at this point is 43 feet. A boring was also made at Dam No. 64, 1,600 feet west of station 4674+40. The first 5 feet developed muck; from 5 feet to 70 feet quicksand or very fine sand. Dam No. 64 is, however, a low dam, raising the water only about 15 feet, and there is no reason why, with thorough construction, a water-tight structure can not be made even on this unpromising material.

A boring was made also at station 4711, which developed muck for the first 8 feet and white sand from 8 feet to 13 feet.

The last boring was at station 4786, at site of Dam No. 65, which developed for the first 19 feet red sand, and from 19 to 30 feet clay with 20 per cent of coarse gravel, which is reported to easily hold water. As regards borings at Dam No. 66, the main ship canal survey made a boring at station 3239+62, which is reported as developing rock 28 feet below the surface. Estimates for Dam No. 66, the main angle of which is about 500 feet north of the said bore hole, have been prepared on this basis.

Dam No. 66, barring Canada Creek, has been provided with a spillway 400 feet in length and with paved wasteway below. This is more spillway than is actually required for the flood flows of Canada Creek, but it is considered that, due to the relation which this portion of the feeder bears to the summit level, a portion of the flood flows of Mohawk River may be discharged over this spillway. The water surface elevation of the pond above Dam No. 66 has been placed at 415, which is the same as the summit level of the ship canal.

Dam No. 65 A is a vertical drop, whereby the feeder water is carried from the high level of the sand plain section to the ship canal summit level.

A review of the borings easily shows that the difficult section for construction is that through the sand plains, from station 4577 + 40 to about station 4797 + 50, a distance of 4.17 miles. For a portion of the way the material is dry, not possessing the quality of water-tightness. This section, while, as shown on the profile, in deep cut, may be expected to excavate cheaply and expeditiously at the portions where water will be likely to give trouble. The estimates provide for 2 to 1 slopes, covered with a stiff puddle composed of sand, gravel, and clay, mixed in such proportion as to insure the maximum degree of stiffness, and, as an extra precaution, to be held in place by a rough riprap. It is proposed to extend the puddle and riprap a few feet above the water surface in order to provide against dangerous erosion at time of flood flows. Above the puddle and riprap the slopes are to be further protected by growths of willows. There are a few other points along the feeder line where similar protection with willows would be desirable and which have been provided for in the estimates.

TABLE NO. 134.—*Showing quantity of water to be furnished by streams tributary to proposed feeder line and main canal, together with the quantity to be taken from Black River by the open feeder, 1892 to 1898, inclusive.*

[In cubic feet per second.]

Month.	Total quantity required.	Streams to north of trout brook, as per Table No. 4.	Trout brook and streams south, as per Table No. 8.	Salmon River Reservoir.	Oriskany and adjacent creeks. Genesee River data, as per Table No. 3.	Upper Mohawk. Mean of Hudson and Genesee rivers data, as per Table No. 9.	Total of columns (3) to (7), inclusive.	Quantity from Black River, column (2)—column (8).	Column (9) in inches, Black River catchment area.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1892.									
December	....	228	844	....	314	317	1,703	....	....
January	....	171	1,856	....	235	549	2,811	....	....
February	....	384	912	....	528	404	2,228	....	....
March	....	426	1,075	....	585	465	2,551	....	....
April	....	502	2,120	....	689	765	4,076	....	....
May	1,600	385	1,931	....	528	665	3,509	....	....
June	1,600	320	1,220	....	440	454	2,434	....	....
July	1,600	453	1,168	....	622	500	2,743	....	....
August	1,600	290	540	104	399	267	1,600	....	....
September	1,600	54	438	300	75	134	1,001	599	0.37
October	1,600	70	277	300	96	102	845	755	0.50
November	1,600	129	749	295	178	249	1,600	....	....
1893.									
December	....	319	398	....	438	244	1,399	....	....
January	....	430	314	....	591	272	1,607	....	....
February	....	314	473	....	431	261	1,479	....	....
March	....	508	812	....	697	434	2,451	....	....
April	....	567	1,720	....	779	714	3,780	....	....
May	1,600	571	2,194	....	785	815	4,365	....	....
June	1,600	80	473	300	109	156	1,118	482	0.30
July	1,600	66	248	300	90	92	796	804	0.51
August	1,600	77	493	300	106	160	1,136	464	0.30
September	1,600	75	676	300	103	206	1,360	440	0.27
October	1,600	88	381	300	121	138	1,028	774	0.49
November	1,600	123	358	300	160	146	1,096	704	0.43
1894.									
December	....	514	710	....	706	411	2,341	....	....
January	....	307	665	....	422	307	1,701	....	....
February	....	209	476	....	287	215	1,177	....	....
March	....	728	1,451	....	1,000	695	3,874	....	....
April	....	767	1,092	....	1,055	622	3,536	....	....
May	1,600	972	745	....	1,334	624	3,675	....	....
June	1,600	248	684	38	341	289	1,600	....	....
July	1,600	31	312	300	43	93	779	821	0.52
August	1,600	47	243	300	65	83	738	862	0.55
September	1,600	210	182	300	289	140	1,121	479	0.30
October	1,600	96	359	300	132	146	1,033	567	0.36
November	1,600	185	627	291	254	243	1,600	....	....
1895.									
December	....	134	430	....	184	170	918	....	....
January	....	143	381	....	196	161	881	....	....
February	....	53	349	....	73	113	588	....	....
March	....	427	414	....	586	296	1,723	....	....
April	....	456	2,352	....	626	804	4,238	....	....
May	1,600	41	674	300	57	190	1,262	338	0.22
June	1,600	30	277	300	41	84	732	868	0.53
July	1,600	25	222	300	34	68	649	951	0.60
August	1,600	27	384	300	37	110	858	742	0.47
September	1,600	24	259	300	32	76	691	909	0.56
October	1,600	25	259	300	34	77	695	905	0.58
November	1,600	106	829	260	146	259	1,600	....	....
1896.									
December	....	565	1,072	....	398	403	2,438	....	....
January	....	103	688	....	142	216	1,149	....	....
February	....	215	459	....	295	213	1,182	....	....
March	....	660	1,339	....	906	636	3,541	....	....
April	....	768	2,460	....	1,055	970	5,253	....	....
May	1,600	37	454	300	51	132	974	626	0.40
June	1,600	88	466	300	121	158	1,133	467	0.29
July	1,600	52	273	300	73	93	791	809	0.52
August	1,600	45	241	300	61	81	728	872	0.56
September	1,600	35	228	300	48	73	684	916	0.56
October	1,600	394	417	....	541	279	1,631	....	....
November	1,600	209	1,314	....	287	428	2,238	....	....

Table No. 134.—*Showing quantity of water to be furnished by streams tributary to proposed feeder line and main canal, etc.*—Continued.

Month.	Total quantity required.	Streams to north of trout brook, as per Table No. 4.	Trout brook and streams south, as per Table No. 8.	Salmon River Reservoir.	Oriskany and adjacent creeks. Genesee River data, as per Table No. 3.	Upper Mohawk. Mean of Hudson and Genesee rivers data, as per Table No. 9.	Total of columns (3) to (7), inclusive.	Quantity from Black River, column (2)—column (8).	Column (9) in inches, Black River catchment area.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1897.									
December	....	174	680	....	238	251	1,343	....	....
January	....	173	394	....	235	177	979	....	....
February	....	192	383	....	264	184	1,023	....	....
March	....	581	1,104	....	799	541	3,025	....	....
April	....	297	1,880	....	409	612	3,198	....	....
May	1,600	218	1,196	....	299	402	2,115	....	....
June	1,600	100	1,168	....	137	343	1,748	....	....
July	1,600	101	1,061	....	139	316	1,617	....	....
August	1,600	97	811	....	133	650	1,691	....	....
September	1,600	41	227	300	56	76	700	900	0.57
October	1,600	40	248	300	54	80	722	878	0.54
November	1,600	84	981	133	115	287	1,600	....	....
1898.									
December	....	229	1,352	....	287	415	2,283	....	....
January	....	428	760	....	589	377	2,154	....	....
February	....	450	665	....	618	280	2,013	....	....
March	....	603	1,990	....	830	779	4,202	....	....
April	....	373	1,360	....	513	513	2,759	....	....
May	1,600	265	1,092	....	377	401	2,135	....	....
June	1,600	182	520	300	250	214	1,466	134	0.08
July	1,600	99	253	300	136	109	897	703	0.45
August	1,600	176	501	300	241	206	1,424	176	0.11
September	1,600	109	371	300	150	143	1,073	527	0.33
October	1,600	171	777	141	236	275	1,600	....	....
November	1,600	444	908	....	610	430	2,392	....	....

Table No. 135.—*Showing quantity of water to be furnished by streams tributary to proposed alternative tunnel line and main canal, together with the quantity to be taken from Salmon and Black rivers reservoir, 1892 to 1898, inclusive.*

Month.	Amount required in cubic feet per second.	Salmon River Reservoir (cubic feet per second).	Fish Creek catchment area. East and west branches. Area—380 square miles. Hudson River data. In cubic feet per second.	Oriskany and adjacent creeks. (Genesee River data (cubic feet per second).	Upper Mohawk. Mean of Hudson and Genesee rivers data (cubic feet per second).	Total of columns (3 to 6), inclusive (cubic feet per second).	Amounts from Black River, column (2)—column (7) (cubic feet per second).	Column (8) in inches on Black River catchment area.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1892.								
December	....	......	721	314	317	1,352	....	....
January	....	......	1,578	235	549	2,362	....	....
February	....	......	778	528	404	1,710	....	....
March	....	......	970	585	465	2,020	....	....
April	....	......	1,812	689	765	3,266	....	....
May	1,200	......	1,651	528	665	2,844	....	....
June	1,200	......	1,090	440	454	1,984	....	....
July	1,200	......	987	622	500	2,109	....	....
August	1,200	73	461	399	267	1,200	....	....
September	1,200	300	374	75	134	883	317	0.20
October	1,200	300	238	96	102	736	464	0.30
November	1,200	134	639	178	249	1,200	....	....

Table No. 135.—*Showing quantity of water to be furnished by streams tributary to proposed alternative tunnel line and main canal, etc.*—**Continued.**

Month.	Amount required in cubic feet per second.	Salmon River Reservoir (cubic feet per second).	Fish Creek catchment area. East and west branches. Area 380 square miles. Hudson River data. In cubic feet per second.	Oriskany and adjacent creeks. Genesee River data (cubic feet per second).	Upper Mohawk. Mean of Hudson and Genesee rivers data (cubic feet per second).	Total of columns (3) to (6), inclusive (cubic feet per second).	Amounts from Black River, column (2)—column (7) (cubic feet per second).	Column (8) in inches on Black River catchment area.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1893.								
December	....	....	340	438	244	1,022	....	....
January	....	....	465	591	272	1,328	....	....
February	....	....	405	431	261	1,097	....	....
March	....	....	692	697	434	1,823	....	....
April	....	....	1,463	779	714	2,956	....	....
May	1,200	....	1,856	785	815	3,456	....	....
June	1,200	300	406	109	156	971	229	0.14
July	1,200	300	212	90	92	694	506	0.32
August	1,200	300	424	106	160	990	210	0.13
September	1,200	300	575	103	206	1,184	16	0.10
October	1,200	300	328	121	136	885	315	0.20
November	1,200	300	307	169	146	922	278	0.17
1894.								
December	....	....	607	706	411	1,724	....	....
January	....	....	568	422	307	1,297	....	....
February	....	....	407	287	215	909	....	....
March	....	....	1,234	1,000	695	2,929	....	....
April	....	....	930	1,055	622	2,607	....	....
May	1,200	....	638	1,334	624	2,596	....	....
June	1,200	....	585	341	289	1,215	....	....
July	1,200	300	267	43	93	703	497	0.32
August	1,200	300	209	65	83	657	543	0.35
September	1,200	300	156	289	140	885	315	0.20
October	1,200	300	307	132	146	885	315	0.20
November	1,200	165	538	254	243	1,200	....	....
1895.								
December	....	....	368	184	170	722	....	....
January	....	....	325	196	161	682	....	....
February	....	....	299	73	113	485	....	....
March	....	....	354	586	296	1,236	....	....
April	....	....	2,011	626	804	3,441	....	....
May	1,200	300	574	57	190	1,121	79	0.05
June	1,200	300	235	41	84	660	540	0.34
July	1,200	300	191	34	68	593	607	0.39
August	1,200	300	329	37	110	776	424	0.27
September	1,200	300	222	32	76	630	570	0.35
October	1,200	300	222	34	77	633	567	0.36
November	1,200	90	705	146	259	1,200	....	....
1896.								
December	....	....	912	398	403	1,713	....	....
January	....	....	587	142	216	945	....	....
February	....	....	392	295	213	900	....	....
March	....	....	1,138	906	636	2,680	....	....
April	....	....	2,103	1,055	970	4,128	....	....
May	1,200	300	387	51	132	870	330	0.21
June	1,200	300	402	121	158	981	219	0.14
July	1,200	300	235	73	93	701	499	0.32
August	1,200	300	207	61	81	649	551	0.35
September	1,200	300	194	48	73	615	585	0.36
October	1,200	26	354	541	279	1,200	....	....
November	1,200	....	1,117	287	428	1,832	....	....
1897.								
December	....	....	579	238	251	1,068	....	....
January	....	....	335	235	177	747	....	....
February	....	....	327	264	184	775	....	....

TABLE NO. 135.—*Showing quantity of water to be furnished by streams tributary to proposed alternative tunnel line and main canal, etc.*—**Continued.**

Month.	Amount required in cubic feet per second.	Salmon River Reservoir (cubic feet per second).	Fish Creek catchment area. East and west branches. Area = 380 square miles. Hudson River data. In cubic feet per second.	Oriskany and adjacent creeks. Genesee River data (cubic feet per second).	Upper Mohawk. Mean of Hudson and Genesee rivers data (cubic feet per second).	Total of columns (3) to (6), inclusive (cubic feet per second).	Amounts from Black River, column (2)—column (7) (cubic feet per second).	Column (8) in inches on Black River catchment area.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1897.								
March	....	....	936	799	541	2,276	....	....
April	....	....	1,599	409	612	2,620	....	....
May	1,200	....	1,018	299	402	1,719	....	....
June	1,200	....	994	137	343	1,474	....	....
July	1,200	....	905	139	316	1,360	....	....
August	1,200	....	782	133	650	1,565	....	....
September	1,200	300	185	56	76	617	583	0.36
October	1,200	300	232	54	80	666	534	0.34
November	1,200	....	836	115	287	1,238	....	....
1898.								
December	....	....	1,150	287	415	1,852	....	....
January	....	....	648	589	377	1,614	....	....
February	....	....	568	618	280	1,466	....	....
March	....	....	1,701	830	779	3,310	....	....
April	....	....	1,157	513	513	2,183	....	....
May	1,200	....	922	377	401	1,700	....	....
June	1,200	292	444	250	214	1,200	....	....
July	1,200	300	216	136	109	761	139	0.28
August	1,200	300	428	241	206	1,175	25	0.02
September	1,200	300	317	150	143	910	290	0.18
October	1,200	28	661	236	275	1,200	....	....
November	1,200	....	773	610	430	1,813	....	....

TABLE No. 136.—*Showing state of proposed Black River Reservoir from month to month, 1892 to 1898, inclusive, with draft therefrom by the proposed alternative tunnel line, as per column (8) of Table No. 135, and with 2,200 cubic feet per second going to Black River.*

[In inches on the tributary catchment area of 1,812.2 square miles.]

Month.	Run-off. Inflow to reservoir.	Outgo from reservoir.				Excess.	Deficiency.	In reservoir at end of month.	Wasted from reservoir.
		Evaporation.	To stream 2,200 cubic feet per second.	To canal.	Total outgo.				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1892.									
December	2.27	0.05	1.40	....	1.45	0.82	....	0.82	....
January	4.83	0.02	1.40	....	1.42	3.41	....	4.23	....
February	2.22	0.03	1.26	....	1.29	0.93	....	5.16	....
March	2.80	0.06	1.40	....	1.46	1.34	....	6.50	....
April	5.35	0.11	1.35	....	1.46	3.89	....	10.39	....
May	5.03	0.14	1.40	....	1.54	3.49	....	13.50	0.38
June	3.08	0.18	1.35	....	1.53	1.55	....	13.50	1.55
July	2.38	0.24	1.40	....	1.64	0.74	....	13.50	0.74
August	1.41	0.19	1.40	....	1.59	....	0.18	13.32	....
September	1.10	0.17	1.35	0.20	1.72	....	0.62	12.70	....
October	0.72	0.11	1.40	0.30	1.81	....	1.09	11.61	....
November	1.89	0.06	1.35	....	1.41	0.48	....	12.09	....
Total	33.08	1.36	16.46	0.50	18.32	....	1.89	....	2.67
1893.									
December	1.03	0.05	1.40	....	1.45	....	0.42	11.67	....
January	0.82	0.02	1.40	....	1.42	....	0.60	11.07	....
February	1.09	0.03	1.26	....	1.29	....	0.20	10.87	....
March	2.11	0.06	1.40	....	1.46	0.65	....	11.52	....
April	4.44	0.11	1.35	....	1.46	2.98	....	13.50	1.00
May	5.71	0.13	1.40	....	1.53	4.18	....	13.50	4.18
June	1.19	0.18	1.35	0.14	1.67	....	0.48	13.02	....
July	0.65	0.23	1.40	0.32	1.95	....	1.30	11.72	....
August	1.28	0.20	1.40	0.13	1.73	....	0.45	11.27	....
September	1.70	0.12	1.35	0.10	1.57	0.13	....	11.40	....
October	0.99	0.11	1.40	0.20	1.71	....	0.72	10.68	....
November	0.90	0.06	1.35	0.17	1.58	....	0.68	10.00	....
Total	21.91	1.30	16.46	1.06	18.82	....	....	....	5.18
1894.									
December	1.85	0.05	1.40	....	1.45	0.40	....	10.40	....
January	1.73	0.02	1.40	....	1.42	0.31	....	10.71	....
February	1.12	0.03	1.26	....	1.29	....	0.17	10.54	....
March	3.78	0.06	1.40	....	1.46	2.32	....	12.86	....
April	2.76	0.10	1.35	....	1.45	1.31	....	13.50	0.67
May	1.94	0.13	1.40	....	1.53	0.41	....	13.50	0.41
June	1.76	0.14	1.35	....	1.49	0.27	....	13.50	0.27
July	0.81	0.21	1.40	0.32	1.93	....	1.12	12.38	....
August	0.63	0.25	1.40	0.35	2.00	....	1.37	11.01	....
September	0.47	0.14	1.35	0.20	1.69	....	1.22	9.79	....
October	0.94	0.10	1.40	0.20	1.70	....	0.76	9.03	....
November	1.58	0.05	1.35	....	1.40	0.18	....	9.21	....
Total	19.37	1.28	16.46	1.07	18.81	....	....	....	1.35
1895.									
December	1.12	0.05	1.40	....	1.45	....	0.33	8.88	....
January	0.99	0.02	1.40	....	1.42	....	0.43	8.45	....
February	0.82	0.03	1.26	....	1.29	....	0.47	7.98	....
March	1.08	0.06	1.40	....	1.46	....	0.38	7.60	....
April	5.91	0.10	1.35	....	1.45	4.46	....	12.06	....
May	1.76	0.12	1.40	0.05	1.57	0.19	....	12.25	....
June	0.70	0.20	1.35	0.34	1.89	....	1.19	11.06	....
July	0.66	0.21	1.40	0.39	2.00	....	1.34	9.72	....
August	1.00	0.19	1.40	0.27	1.86	....	0.86	8.86	....
September	0.65	0.19	1.35	0.35	1.89	....	1.24	7.62	....
October	0.69	0.12	1.40	0.36	1.88	....	1.19	6.43	....
November	2.08	0.04	1.35	....	1.39	0.69	....	7.12	....
Total	17.46	1.33	16.46	1.76	19.55	....	....	..	....
1896.									
December	2.79	0.04	1.40	....	1.44	1.35	....	8.47	....
January	1.74	0.02	1.40	....	1.42	0.32	....	8.79	....

TABLE No. 136.—*Showing state of proposed Black River Reservoir from month to month, 1892 to 1898, inclusive, etc.*—**Continued.**

Month.	Run-off. Inflow to reservoir.	Outgo from reservoir.				Excess.	Deficiency.	In reservoir at end of month.	Wasted from reservoir.
		Evaporation.	To stream 2,200 cubic feet per second.	To canal.	Total outgo.				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1896.									
February	1.12	0.02	1.26	....	1.28	....	0.16	8.63	....
March	3.49	0.03	1.40	....	1.44	2.06	....	10.69	....
April	6.20	0.10	1.35	....	1.45	4.75	....	13.50	1.94
May	1.18	0.20	1.40	0.21	1.81	....	0.63	12.87	....
June	1.18	0.20	1.35	0.14	1.69	....	0.51	12.36	....
July	0.72	0.17	1.40	0.32	1.89	....	1.17	11.19	....
August	0.63	0.18	1.40	0.35	1.93	....	1.30	9.89	....
September	0.71	0.12	1.35	0.36	1.83	....	1.12	8.77	....
October	1.05	0.08	1.40	....	1.48	....	0.43	8.34	....
November	2.82	0.05	1.35	....	1.40	1.42	....	9.76	....
Total	23.63	1.21	16.46	1.38	19.05	....	....	....	1.94
1897.									
December	1.77	0.05	1.40	....	1.45	0.32	....	10.08	....
January	1.03	0.02	1.40	....	1.42	....	0.39	9.69	....
February	0.90	0.03	1.26	....	1.29	....	0.39	9.30	....
March	4.07	0.07	1.40	....	1.47	2.60	....	11.90	....
April	5.44	0.10	1.35	....	1.45	3.99	....	13.50	2.39
May	4.97	0.13	1.40	....	1.53	3.44	....	13.50	3.44
June	1.74	0.19	1.35	....	1.54	0.20	....	13.50	0.20
July	0.74	0.17	1.40	....	1.57	....	0.83	12.67	....
August	1.44	0.20	1.40	....	1.60	....	0.16	12.51	....
September	0.68	0.18	1.35	0.36	1.89	....	1.21	11.30	....
October	0.65	0.12	1.40	0.34	1.86	....	1.21	10.09	....
November	2.56	0.05	1.35	....	1.40	1.16	....	11.25	....
Total	25.99	1.31	16.46	0.70	18.47	....	....	....	6.03
1898.									
December	3.17	0.04	1.40	....	1.44	1.73	....	12.98	....
January	2.35	0.02	1.40	....	1.42	0.93	....	13.50	0.41
February	2.24	0.04	1.26	....	1.30	0.94	....	13.50	0.94
March	6.63	0.06	1.40	....	1.46	5.17	....	13.50	5.17
April	3.20	0.13	1.35	....	1.48	1.72	....	13.50	1.72
May	2.25	0.15	1.40	....	1.55	0.70	....	13.50	0.70
June	1.15	0.23	1.35	....	1.58	....	0.43	13.07	....
July	0.87	0.26	1.40	0.28	1.94	....	1.07	12.00	....
August	1.07	0.19	1.40	0.02	1.61	....	0.54	11.46	....
September	1.02	0.15	1.35	0.18	1.68	....	0.66	10.80	....
October	2.16	0.10	1.40	....	1.50	0.66	....	11.46	....
November	2.69	0.06	1.35	....	1.41	1.28	....	12.73	....
Total	28.80	1.43	16.46	0.48	18.37	....	....	....	8.94

Referring to Table No. 134, showing quantity of water to be furnished by streams tributary to the proposed feeder line and main canal, together with the quantity to be taken from Black River, 1892 to 1898, inclusive, it is shown in column (9) that in 1892 water would only have been taken from Black River reservoir to the mean amount of 599 cubic feet per second in September and 755 cubic feet per second in October. In 1893 the tabulated quantities are: June, 482 cubic feet per second; July, 804 cubic feet; August, 464 cubic feet; September, 440 cubic feet; October, 774 cubic feet; and November, 704 cubic feet per second. In 1894 the quantities are: July, 821 cubic feet per second; August, 862 cubic feet; September, 479 cubic feet; and October, 567 cubic feet per second. In 1895 the quantities are: May, 338 cubic feet per second; June, 868 cubic feet; July, 951 cubic feet; August, 742 cubic feet; September, 902 cubic feet; and October, 905 cubic feet per second. In 1896 the quantities are: May, 626 cubic feet per second; June, 467 cubic feet; July, 819 cubic feet per second; August, 872 cubic feet; and in September, 916 cubic feet per second. In 1897 the quantities are: September, 900 cubic feet per second, and October, 878 cubic feet per second. In 1898 the quantities are: June, 134 cubic feet per second; July, 703 cubic feet; August, 176 cubic feet, and September, 527 cubic feet per second.

The question may with propriety be asked, if the foregoing monthly quantities are all that is to be taken from Black River reservoir, why a feeder line carrying from 1,000 to 1,600 cubic feet per second has been designed. The answer is (1) that the water supply of any ship canal of the magnitude of that now under discussion must be absolutely beyond question. Table No. 133, giving the computed outgo of Salmon River reservoir, shows that under the actual conditions of run-off for the years 1892 to 1898, inclusive, there would have been left in that reservoir—with an outgo of 300 cubic feet per second, from May to November, inclusive—at the end of the month of November, 1895, 5.19 inches on the catchment area. An accidental stoppage of the feeder to north of Salmon River for even a few days in 1895 would have exhausted this surplus, requiring a draft of the 300 cubic feet per second which Salmon River reservoir is tabulated to furnish from Black River reservoir, thus increasing the quantities of column (9) of Table No. 134 by 300 cubic feet per second, and immediately bringing us for the maximum months (as, for instance, September and October, 1895) to and above the 1,100 cubic feet per second which the main section of the feeder between Sandy Creek and Kasoag ponds is nominally designed to carry. At this point of the argument the question may be further raised, is the water supply as here designed absolutely beyond question so long as it appears necessary to provide for the contingency of any interruption to north of Salmon River? To this proper question the answer is, that the length of artificial channel from Salmon River (station 2658+50) to Upper Kasoag pond (station 2840) is only 3.44 miles. This section of the canal is laid through swamp, where there is no conceivable possibility of interruption from breaks or the ordinary accidents of operation of such a channel. There are no high dams to give way, and the Salmon River dam (No. 47) is founded on rock and designed with such liberal factor of safety as to be beyond the possibility of any accident except an earthquake, proper construction being assumed. From Kasoag ponds to where the feeder leaves West Branch of Fish Creek (station 4297+70), for a distance of 27.61 miles, the feeder water flows through the valley of West Branch, where it is entirely beyond the mutations of accident. From station 4297+70 to Dam No. 63 (station 4560+80) the construction must necessarily be of the most permanent character. As already stated, there is no reason why, with such construction, this section, while somewhat expensive, can not be made safe. From station 4577+40 to point of junction with main ship canal summit level at station 4896+70 there is no reason to assume the possibility of any accident to feeder. The argument appears clear, therefore, that a full water supply may always be delivered from Salmon River to the main summit level, whatever may happen to the north of that stream. The broad proposition is that the comparatively small length of artificial feeder between Salmon River and the main summit level is an absolute guaranty of safety.

Moreover, there is no reason to suppose that the upper section from Carthage to Salmon River is subject to greater mutations than the section south of Salmon River. Even though the upper section is required to carry at times considerable flood flows, it is believed that the design has been worked out on sufficiently broad lines to permit of carrying such without accident. The Salmon River reservoir is, therefore, in effect, a double insurance.

Further, as to the capacity of the feeder from Carthage to Kasoag summit, it may be remarked that while the several computations herewith submitted are all based on the actual run-off record of Hudson River for the years stated—1892 to 1898, inclusive—nevertheless we have no guaranty that this series of years does actually include the year of minimum run-off. Indeed, when we study the meteorology of central and northern New York broadly, as exhibited in detail in Tables Nos. 20 to 118, inclusive, it appears very certain that this record does not include the absolute minimum year. It is evident there has been some year in the past, and must inevitably be some year in the future, when the yield of streams tributary to summit level, Black River feeder, and Salmon and Black rivers reservoirs will be less than in 1895, which is the minimum year of the series here used. On Hudson River, with a minimum run-off in the water year 1895 of 17.46 inches for the whole year, the rainfall for that year was between 36 and 37 inches. In case the rainfall of Hudson River catchment area should ever sink as low as 30 inches for a water year, we may expect a total run-off for that year of between 9 and 10 inches. On Genesee River we have actually had, in 1895, for a rainfall of 31 inches, a run-off of only 6.67 inches. As the result of extensive studies of the hydrology of New York State, it is the author's opinion that should rainfall of northern plateau (as it is believed it will) fall to about 30 inches, and such low precipitation be at all general throughout the catchment areas tributary to deep waterways, the tributary streams from Trout Brook south, including west and east branches of Fish Creek, Salmon River, Oriskany, and adjacent creeks, upper Mohawk and other tributary streams would be nearly dry, necessitating for periods of from sixty to ninety days of such year, aside from the water furnished by Salmon River reservoir, that substantially the entire water supply of deep-waterways summit level must be taken from Black River reservoir. It is from this point of view that Black River reservoir has been designed on such liberal scale as to leave therein in 1895, at the end of November, a storage of 5.26 inches on the catchment area. This quantity is believed to be no more than sufficient to safely tide over the minimum dry year, which sooner or later will certainly arrive. For perfect safety about that quantity of water must (however liberal the flow of wet years) be held in store as a reserve against the year of extreme minimum flow. It follows, therefore, that the dimensions of the feeder, as here proposed, are conservative.

The author has assumed in this design that the subject must be treated broadly and, in view of the magnitude of the interests involved, that ordinary, small economies are not permissible.

Reference has already been made to Table No. 134, showing quantity of water to be furnished by streams tributary to proposed feeder line and main canal, together with the quantity to be taken from Black River, 1892 to 1898, inclusive. We will now consider this table in detail:

Column (2) gives the assumed total quantity required of 1,600 cubic feet per second, the assumption being that for the month of April the tributary streams will always furnish the required quantity; column (3) gives the quantity to be furnished by streams to north of Trout Brook, as per Table No. 4; column (4), quantity furnished by Trout Brook and streams to south, as per Table No. 8; column (5), the amount from Salmon River reservoir; column (6), the amount from Oriskany and adjacent creeks based on Genesee River data, as per Table No. 3; column (7), the amount from upper Mohawk, as based on a mean of Hudson and Genesee rivers data, as per Table No. 9. Column (8) gives the total of columns (3) to (7), inclusive, or the total amount which may be expected from the indicated streams in each month; column (9) shows the mean quantity in cubic feet per second to be taken in any month from Black River, being the difference of columns (2) and (8), and column (10) gives column (9) in inches on Black River catchment area for use in Table No. 131, showing state of proposed Black River reservoir from month to month, 1892 to 1898, inclusive, with draft therefrom, as per column (10) of the previous table, and with 2,200 cubic feet per second going to Black River.

Column (2) of this table gives the run-off, as per Hudson River data, for each month, which equals inflow to reservoir, the assumption being, as stated on a previous page, that Hudson River data apply to Black River. The outgo from reservoir, consisting of evaporation, amount to stream of 2,200 cubic feet per second, and amount to canal is shown by columns (3), (4), and (5), the total outgo, or sum of columns (3), (4), and (5), being given in column (6). Columns (7) and (8) show the excess and discrepancy figures, as already described in discussing Table No. 133, applying to Salmon River reservoir.

Column (9) gives the amount in reservoir at the end of each month, and column (10) the amount wasted from reservoir in any given month. Column (11) gives the elevation of water surface in reservoir at the end of each month, and column (12) the cubic contents of reservoir at the end of each month in cubic feet. Aside from columns (11) and (12), the balance of this table is computed in inches on the tributary catchment area of 1,812.2 square miles. The general method of computation of these tables is believed to be so plain as not to require further explanation.

The location of highway bridges, guard gates, and changes of highway are shown on the maps. Highway bridges have been estimated as substantial steel structures designed to carry a uniform load of 75 pounds per square foot and a concentrated load represented by a 15-ton steam road roller, and with substantial masonry abutments.

Guard gate No. 1 is located at station 318, just west of the Townsend Brook pond, at a distance of 6.2 miles from Carthage. The elevation of surface of canal at gate is 721.3 feet. The natural catchment area above gate and tributary to the canal at that point is 16.1 square miles.

Guard gate No. 2 is located on the west side of highway at station 700. The elevation of water surface at gate is 715.9 feet. One thousand five hundred feet above there is a waste way 100 feet long. The catchment area between gates Nos. 1 and 2 is 7.8 square miles.

Gate No. 3 is located in north side of highway, as changed, at station 1405, a short distance below Sandy Creek pond. The tributary catchment area of Sandy Creek above this gate is 106.4 square miles, controlled by the long spillway of Dam No. 8, already described.

Guard gate No. 4 is at highway at station 1568, just below south branch of Sandy Creek. The ordinary water surface of pond above Dam No. 9 is 657.3. The movable crest of this dam is to be set at elevation 657.8; hence with gate closed, the water may be expected to stand at that level. The tributary catchment area between gates Nos. 3 and 4 is 44.4 square miles. The flood flows will be relieved by a a waste way at Dam No. 9.

Guard gate No. 5 is located at highway at station 1649, just below Loraine Brook and Deer Creek. There is a waste way 200 feet long on Deer Creek 2,600 feet above gate location. There is no spillway at Dam No. 12 on Loraine Brook, the design being that flood water from this stream pass back through the short ridge of canal connecting Loraine Brook with Deer Creek, relieving itself at spillway of Dam No. 11. The ordinary water surface at gate No. 5 is about 655.9 feet, that being the elevation of pond on Loraine Creek. The tributary catchment area between gates Nos. 4 and 5 is 31.6 square miles.

Guard gate No. 6 is located at highway at station 2141, about 9.25 miles below gate No. 5 and 1,800 feet below waste way at Dam No. 29 on Little Sandy Creek, where there is to be a waste way 180 feet long

The ordinary water surface at gate No. 6 is 648.6 feet. The tributary catchment area between gates Nos. 5 and 6 is 40.7 square miles.

Guard gate No. 7 is located at station 2660 at highway just south of Salmon River, at a distance from gate No. 6 of 9.8 miles. The elevation of water surface is 639.1 feet. The long spillway of Salmon River dam, No. 47, will afford relief for tributary drainage above the gate.

Guard gate No. 8 is located at Station 4446, just below East Branch of Fish Creek, where the water surface is 432.5. The long spillways on the two branches of Fish Creek at Dams Nos. 54 and 57 affords relief for the large tributary area above these gates.

Guard gate No. 9 is located at highway at Station 4882, where the water-surface elevation is 415.0. It controls the flow from the feeder into the summit level, the tributary drainage being relieved by the spillway at Dam No. 66.

The guard gates are to be of the Stoney pattern, with clear openings of 30 feet and with depths of from 10 to 20 feet, depending on section of canal at the several points where the guard gates are located, and with substantial abutments of masonry. By locating the guard gates at highways where bridges are required, the consequent construction of the abutments of the bridges in connection with the gate masonry will lead to considerable economy of masonry. They are all located immediately on rock in the bottom of the canal, except Nos. 7, 8, and 9. At No. 7 the rock is about 10 feet below the bottom of the canal; at No. 8 it is probably deep, and a timber or plank foundation will be required; at No. 9 the indications from the main ship-canal boring made in the vicinity are that rock may be expected to be found at a depth of from 28 to 30 feet. In addition to checking flood flows and diverting the same over wasteways, another important feature of the guard gates will be to hold the channel nearly full of water at times when no water is being taken from Black River. They will also be necessary for regulating volume of flow.

From Carthage to Sandy Creek the rock excavation is entirely in Trenton limestone, and from Sandy Creek to about Station 2320, in the shales of the Hudson and Utica groups, the chief development being that known as Loraine shale. South of Station 2320 the rock may be classed as the sandstones of the Oswego group, there being possibly small patches of either the Oneida or Medina group which appear throughout the adjacent region.

As shown by the profile, the feeder, generally speaking, has been so designed, except where valleys are crossed, as to throw the ordinary flow line below the natural surface. In order to show the main characteristics with reference to whether the full depth of cutting is in rock, or partly in rock or in earth, and whether the channel is natural or artificial, the following tabulation has been prepared which, it is believed, when taken in conjunction with the foregoing description, will give all necessary information as to the main characteristics of this feeder canal:

Characteristics of feeder.

Station.	Depth of feeder.	Full depth in rock.		Part depth in rock.		Artificial pond or natural stream.		Full depth in earth.	
		Length.	Material.	Length.	Depth in rock, in feet.	Length.	Artificial or natural.	Length.	Material.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
0-20	10.0								
20-48	17.5			4,800	0-15				
48-53	17.5	500	Limestone						
53-71	17.5			1,800	9-16				
71-78	17.5	700	Limestone						
78-101	17.5			2,300	9-13				
101-256	17.5	15,500	Limestone						
256-259	17.5			300	0-15				
259-262	17.5							300	Sand.
262-265	17.5			300	0-15				
265-298	17.5	3,300	Limestone						
298-306	17.5							800	Hardpan.
306-316	17.5					1,000	Artificial		
316-360	20	4,400	Limestone						
360-378	20			1,800	0-18				
378-384	20							600	Sand.
384-417	20	3,300	Limestone						
417-427	20			1,000	11-17				
427-435	20	800	Limestone						
435-446	20			1,100	15-18				
446-529	20	8,300	Limestone						
529-668	5 to 37					13,900	Artificial		
668-764	18	9,600	Limestone						
764-774	16					1,000	Artificial		
774-777	18							300	Hardpan.
777-916	18	13,900	Limestone						
916-930	10			1,400	6-19				
930-1010	10							8,000	Drainage ditch, Sandy Creek.
1010-1238						22,800	Sandy Creek		
1238-1388	6 to 30					15,000	Artificial		
1388-1394	15	600	Shale						
1394-1398	15			400	0-14				
1398-1406	15							800	Hardpan.
1406-1430	15			2,400	0-12				
1430-1460	15	3,000							
1460-1490	15			3,000	8-13				
1490-1516	15								
1516-1561	15	2,600	Shale			4,500	Artificial		
1561-1603								4,200	Do.
1603-1619		1,600	Shale						
1619-1622								300	Do.
1622-1627						500	Artificial		
1627-1642	15	1,500	Shale						
1642-1644						200	Artificial		
1644-1646	10	200	Shale						
1646-1649	10			300	1-8				
1649-1690	10							5,000	Clay loam.
1690-1731						3,200	Artificial		
1731-1750	10							1,900	Do.
1750-1800	10							5,000	Hardpan.
1800-1809						900	Artificial		
1809-1846	10							3,700	Clay loam, hardpan.
1846-1855						900	Artificial		
1855-1879	10							2,400	Hardpan.
1879-1894						1,500	Artificial		
1894-1904	10							1,000	Clay loam, hardpan.
1904-1919						1,500	Artificial		
1919-1932	10							1,300	Clay loam.
1932-1958						2,600	Artificial		
1958-1997	10							3,900	Hardpan.
1997-2008						1,100	Artificial		
2008-2032	10							2,400	Hardpan and rock.

Characteristics of feeder—Continued.

Station.	Depth of feeder.	Full depth in rock.		Part depth in rock.		Artificial pond or natural stream.		Full depth in earth.	
		Length.	Material.	Length.	Depth in rock, in feet.	Length.	Artificial or natural.	Length.	Material.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2032-2046						1,400	Artificial		
2046-2051	10							500	Hardpan.
2051-2072	15	2,100	Shale						
2072-2076	15			400	1-13				
2076-2083						700	Artificial		
2083-2091	15							800	Do.
2091-2107	15			1,600	1-6				
2107-2113	15							600	Do.
2113-2125	15			1,200	1-12				
2125-2243	15			11,800	4-14				
2243-2265	15							2,200	Gravel and blue clay.
2265-2319	15			5,400	3-13				
2319-2372	15								
2372-2397	15			2,500	1-13				
2397-2450	10							5,300	Gravel and bowlders.
2450-2490	10							4,000	Hardpan.
2490-2638	10							14,800	Sand and gravel.
2638-2658						2,000	Salmon River		
2658-2712	10							5,400	Clay, loam, and gravel.
2712-2752	10							4,000	Muck and gravel.
2752-2790	10							3,800	Gravel.
2790-2810	10							2,000	Gravel and quicksand.
2810-2840	10							3,000	Gravel and sandy loam.
2840-2905						6,500	Kasoag Pond		
2905-4296						139,100	Fish Creek		
4296-4310	10							1,400	Sand, clay, and gravel.
4310-4313						300	Artificial		
4313-4317	10							400	Do.
4317-4327						1,000	Artificial		
4327-4426	10							9,900	Clay, loam, sand, gravel.
4426-4446						2,000	North B. Fish Creek.		
4446-4466	10							2,000	Clay.
4466-4489						2,300	Artificial		
4489-4515	10							2,600	Sand and clay.
4515-4516						100	Artificial		
4516-4526	10							1,000	Do.
4526-4527						100	Artificial		
4527-4531	10							400	Do.
4531-4536						500	Artificial		
4536-4561	10							2,500	Do.
4561-4577						1,600	Artificial		
4577-4650	10							7,300	Fine sand.
4650-4674						2,400	Artificial		
4674-4807	10							13,300	Do.
4807-4832						2,500	Artificial		
4832-4895	10							6,300	Do.
4895-0		77,200		43,800		233,100		135,400	

SUMMARY.

	Per cent.
Length of ponds and streams (233,100 feet)	47.61
Length with rock as high as surface of water (77,200 feet)	15.77
Length with rock bottom and partly on side (43,800 feet)	8.95
Length in earth cut (135,400 feet)	27.67
Total length of feeder (489,500 feet)	100.00

Total length in fine sand, 26,900 lineal feet.

The region through which the Black River feeder line is located is about midway of the long slope from the highlands of Jefferson, Lewis, Oswego, and Oneida counties to Lake Ontario, and is exposed to severe west winds constantly sweeping from that body of water. On this account it was assumed, at the beginning of the study, that some allowance should be made for friction of air upon surface of water in the feeder, not only because of high velocity of flow therein, but because of broad water surfaces. The fundamental formula

$$v=c\sqrt{r\,s}$$

has been used for all the computations. In order to allow for retarding effect of severe winds of this region, which at times continue for several days, the computations were originally based upon a value of

$$r=\frac{\mathrm{A}}{p+\frac{1}{2}\text{ of exposed air surface.}}$$

On further study it was decided to make

$$r=\frac{\mathrm{A}}{p+\frac{1}{4}\text{ of exposed air surface,}}$$

and accordingly a reduction from the computed quantities has been made of 1,000,000 cubic yards of earth, 50,000 cubic yards of Trenton limestone, and 50,000 cubic yards of shale, in order to allow for the resulting reduction of cross sections.

We have in the following tabulation the characteristics of the cross sections as made on the basis of

$$r=\frac{\mathrm{A}}{p+\frac{1}{4}\text{ of exposed air surface.}}$$

The sections drawn upon the profile agree with the figures as per this tabulation.

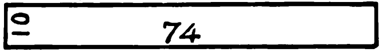
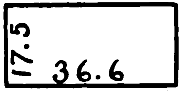
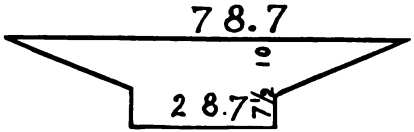
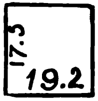
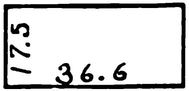
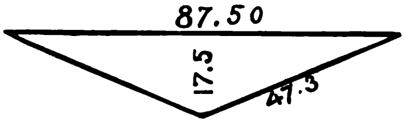
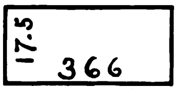
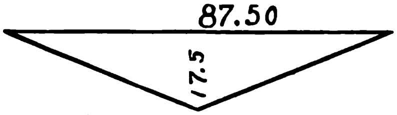
Black River feeder—Characteristics of cross sections adopted.

$v = c\sqrt{rs}$

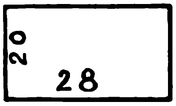
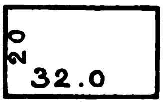
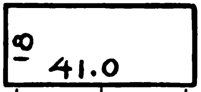
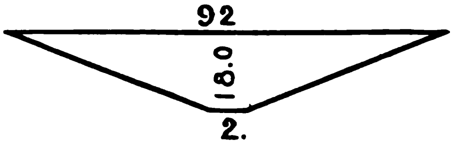
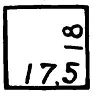
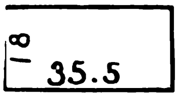
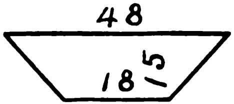
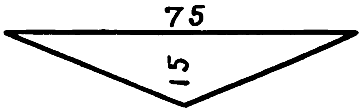
$r = \dfrac{A}{\text{Wetted surface} + \frac{1}{4} \text{ of air surface}}$.

$$c = \frac{41.66 + \frac{1.811}{n} + \frac{0.00281}{s}}{1 + \left(41.66 + \frac{0.00281}{s}\right)\frac{n}{\sqrt{r}}}$$

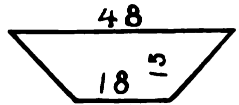
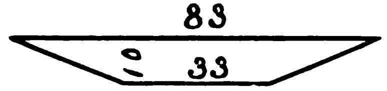
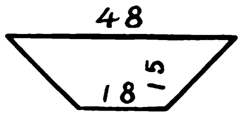
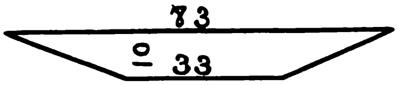
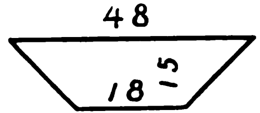
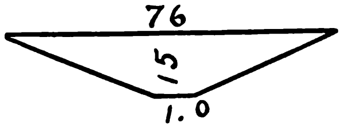
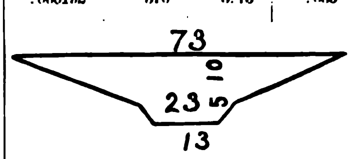
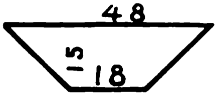
v = feet per second.
Q = cubic feet per second.

Serial number. (1)	Station. (2)	*s* (3)	A (4)	*r* (5)	*n* (6)	*c* (7)	*v* (8)	Q (9)
	0-18	.000192	740	6.60	.035	61	2.17	1,606
1		 10 74						
	20-81	.000192	640	7.93	.035	64	2.49	1,594
2			 17.5 36.6					
	82-107	.000192	752	6.37	.035	61	2.13	1,604
3		 78.7 10 28.7 7½						
	108+30-192	.000911	336	5.67	.031	66	4.74	1,594
4				 17.5 19.2				
	194-256	.000192	640	7.93	.035	64	2.49	1,594
5			 17.5 36.6					
	258-262	.000192	745	6.39	.035	61	2.14	1,594
6		 87.50 17.5 47.3						
	264-298	.000192	640	7.93	.035	64	2.49	1,594
7			 17.5 366					
	300-304	.000192	745	6.39	.035	61	2.14	1,594
8		 87.50 17.5						

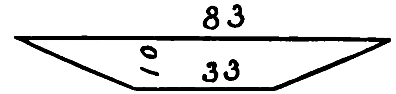
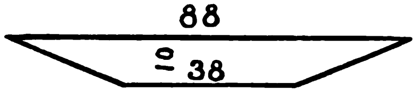
Black River feeder—Characteristics of cross sections adopted—**Continued.**

Serial number.	Station.	*s*	A	*r*	*n*	*c*	*v*	Q
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
9	318-412	.000287	560	7.46	.035	62	2.86	1,601
								
10	412-525	.000192	640	8.00	.035	64	2.50	1,600
								
11	670-764	.000134	738	8.48	.035	65	2.19	1,617
								
12	776-778	.000134	846	6.93	.035	63	1.92	1,624
								
13	780-860	.001136	315	5.43	.031	65	5.10	1,606
								
14	860-930	.000192	639	7.94	.035	64	2.50	1,598
								
15	1388-1398	.000192	495	6.87	.035	62	2.25	1,114
								
16	1398-1424	.000192	563	5.69	.035	60	1.98	1,116
								

Black River feeder—Characteristics of cross sections adopted—Continued.

Serial number.	Station.	s	A	r	n	c	v	Q
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
17	1428-1514	.000192	495	6.87	.035	62	2.25	1,114
								
18	1562-1598	.000192	580	5.37	.035	59	1.89	1,099
								
19	1604-1640	.000192	495	6.87	.035	62	2.25	1,114
								
20	1646-2050	.000192	580	5.37	.035	59	1.89	1,099
								
21	2052-2074	.000192	495	6.87	.035	62	2.25	1,114
								
22	2084-2092	.000192	578	5.67	.035	59	1.94	1,125
								
23	2094-2266	.000192	570	5.75	.035	59	1.96	1,117
								
24	2268-2284	.000192	495	6.87	.035	62	2.25	1,114
								

Black River feeder—Characteristics of cross sections adopted—Continued.

Serial number.	Station.	*s*	A	*r*	*n*	*c*	*v*	Q
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
25	2386-2840	.000192	580	5.37	.035	59	1.89	1,099
								
26	4296-4886	.000192	630	5.53	.035	59	1.92	1,211
								

We will now consider evaporation and percolation losses on feeder line, first considering separately the section from Carthage to Sandy Creek (Dam No. 8). On this section the exposed water surface, including feeder channel and ponds, may be taken at about 56,100,000 square feet. On the basis of the Rochester data we have a maximum evaporation for the month of July of 6.85 inches, which would give an evaporation for that month of, roundly, 12 cubic feet per second.

In considering percolation loss we may divide the section between Carthage and Sandy Creek (Dam No. 8) into two parts, one consisting of a channel cut largely in rock and the other of the two reservoirs formed by Dams Nos. 6 and 8 in Rutland Hollow and Sandy Creek. The channel portion will have a wetted perimeter of about 5,700,000 square feet, with an average depth of water of 13.1 feet.

Mr. Childs estimated for Erie Canal a percolation loss of 180 cubic feet per mile per minute,[1] the section being on an average 75 feet wide at top, 47 feet at bottom, and 8 feet deep, giving an average depth of 6 feet. On this basis we have 438,240 square feet of wetted surface per mile and a percolation per square foot of wetted surface of 0.0041 cubic foot per minute. Assuming percolation as directly proportional to depth, a channel with a depth of 13.1 would show a loss of 0.000894 cubic foot per minute. This gives for the channel from Carthage to Sandy Creek a loss of 5,071 cubic feet per minute, or 84.5 cubic feet per second.

The rock in which this section of the feeder is to be excavated is, as stated, the Trenton limestone in thin layers, probably averaging not more than 4 to 8 inches thick, thus exposing a large number of seams to the water. There are also vertical seams or fissures in the rock at a few surface exposures. Two or three streams on the line disappear into such fissures, reappearing some distance away. The rock beds lie nearly horizontal. The feeder is, moreover, on the sidehill of the valley of Black River, which has been eroded to a considerable depth below the feeder level, so that if seams in the rock are open at all for admission of water, the water may find a passage out and down into the river valley within a short distance. Open seams will not be readily closed by silt, because the water flowing in the canal will, aside from a few days of flood each year, be mostly clear. If one of the seams in every square foot in the exposed face of rock were open 0.01 of a foot and 1 foot in length, and the water passed out at the rate of only 0.1 of a cubic foot per second, such outflow would correspond to a percolation of 84.5 cubic feet per second for less than 100 feet in length of channel. It is improbable, however, that any such extreme percolation would exist for any considerable length of channel, and in any case, if it did, the location of such leakage could be found and the proper remedy applied. However, taking into consideration the observed disappearances of water, as well as the springs coming from sidehills along this part of the feeder, showing small underground passageways, it appears proper to double the foregoing estimate and call the probable loss from percolation between Carthage and Sandy Creek, say, 170 cubic feet per second. In addition to the percolation loss from the feeder channel, there may be expected to be a small loss from the ponds in Rutland Hollow and Sandy Creek for the reasons before mentioned, and for the further reason that Rutland Hollow particularly is several hundred feet above Black River and separated from it by a narrow rock ridge, in which it is probable that the horizontal limestone layers are continuous.

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[1] See report on the water supply of western division of Erie Canal by the author, in Annual Report of State Engineer and Surveyor of New York for 1896.

This will apply with perhaps less force to Sandy Creek Valley, for the reason that the high ground between it and the Lake Ontario slope is wider. The depth of water in both of these ponds will be about 50 feet at the deepest parts. The surface soils now in place above the rock are, however, heavy and tenacious and undoubtedly nearly water-tight; but inasmuch as it is impossible to say that they are absolutely water-tight, we may assume, for purposes of the argument, a rate of percolation one-quarter of that assumed for Erie Canal, whence we compute a possible loss from these reservoirs of about 58 cubic feet per second. The maximum evaporation and percolation loss would then be:

	Cu. ft. per second.
Evaporation	12
Percolation from canal prism	170
Percolation from reservoirs	58
Total	240

On the section from Sandy Creek to outlet of Kasoag ponds the conditions are somewhat different. For a considerable portion of this section the underlying rocks are shale, with tenacious clay surface soils or subsoils possessing the quality of water-tightness. Exceptions to this are, however, noted at a few sections already referred to, but which it is proposed to make water-tight by thorough puddling. The total water surface of this section, including ponds and feeder channel, is 31,240,000 square feet, from which there may be expected in July a maximum evaporation of about 7 cubic feet per second. The wetted perimeter may be taken at 6,000,000 square feet of rock surface, mostly shales and sandstones in thin layers, and 28,000,000 square feet of earth surface. Of the earth surface about 10,000,000 square feet are in feeder channel excavation and 18,000,000 square feet in shallow ponds with the water resting on undisturbed natural surfaces. As may be seen from the maps, the feeder on this section is generally on sidehill, with fairly flat surface slopes on the lower side. In the absence of definite data specifically applying, the following assumptions as to percolation have been made:

From 6,000,000 square feet of rock surface, with an average depth of water of 15 feet, the percolation loss is assumed at 100 cubic feet per second.

From 10,000,000 square feet of excavated earth surface, with depth of water averaging 8 feet, the percolation loss is assumed at 90 cubic feet per second.

From 18,000,000 square feet of ponds, where the percolation may be expected to not exceed one-quarter of the amount allowed for disturbed earth, we may assume a percolation loss of 33 cubic feet per second.

We have then, as the probable maximum evaporation and percolation loss on the section from Sandy Creek to Kasoag (7+100+90+33) =230 cubic feet per second.

In the natural channel of Fish Creek, from Kasoag to where the feeder line leaves West Branch of Fish Creek at station 4297+70 (Dam No. 54), we may assume that there will be no percolation loss, except such as is due to raising the water table at the sides of the stream and which leads to increased evaporation from the ground surface on flat areas. This loss may at times become very large, possibly as much as from 60 to 100 cubic feet per second. In order to have a definite figure, we will assume it at 75 cubic feet per second.

From station 4297 + 70 to where the feeder enters the sand plains at station 4577 + 40 the material through which the feeder is excavated contains enough clay to make water-tight work, but through the sand plains there will be considerable percolation loss, except that the puddling be well done. As a matter of judgment, the evaporation and percolation losses on the lower section are taken at from 40 to 60 cubic feet per second.

Assuming the evaporation and percolation losses for the several sections of the feeder as per the foregoing, we have the following:

	Cu. ft. per second.
Evaporation and percolation loss, Carthage to Sandy Creek	240
Evaporation and percolation loss, Sandy Creek to Kasoag	230
Evaporation and percolation loss, valley of West Branch of Fish Creek	80
Evaporation and percolation loss in channel from West Branch Fish Creek to summit level ship canal	50
Total	600

In considering the foregoing total of 600 cubic feet per second, it should be remembered that this represents the maximum loss likely to occur when the feeder is new. Experience shows that in such channels there is a gradual decrease in the percolation loss for several years, until finally a fixed state is attained, due to silting up of the bottom and sides. The materials through which the feeder will be excavated are of such quality as to assure the maximum effect of such silting. Hence it is the author's opinion that after a few years of operation the evaporation and percolation losses will not exceed 400 cubic feet per second, on which basis the computations of capacity have been made. It is recognized, however, that for the first few years the losses may run as high as 600 cubic feet per second, a fact which is urged as an additional reason for considerable leeway in storage on Black River.

As a final summation of this part of the subject, the author again reiterates his opinion that the Black River storage, if constructed as here proposed, is sufficient to not only supply 2,200 cubic feet per second to Black River every day in the year, but also to meet all possible contingencies of adequate water supply for the Oswego-Mohawk summit level.

In concluding this discussion of the proposed Black River feeder, it may be very properly remarked that the work as presented undoubtedly contains some crudities—as, for instance, no attempt has been made to decrease the cross section on the different sections, as the amount of water passing gradually decreases from evaporation and percolation loss. There is also some slight lack of adjustment to the actual work finally decided upon between the different sections. The quantities given in the estimates are, nevertheless, ample to construct the feeder with all necessary refinements of the character indicated, and taking into consideration that at the best a hurried study of this character is merely in the nature of preliminary work it has not been deemed worth while to spend the time necessary for relatively unimportant final adjustments.

ESTIMATES.

All of the following estimates have been prepared on the basis of an eight-hour day, and with reference to the present tendency, which is to increase somewhat the price of labor. The prices used are given in detail farther on.

Complete estimate of cost of constructing the Black River feeder, together with the Black and Salmon River reservoirs and appurtenances.

BLACK RIVER RESERVOIR.

Right of way:		
Acres—		
800, at $500 (village property)	$400,000	
3,000, at $100	300,000	
3,000, at $80	240,000	
2,000 at $60	120,000	
1,000, at $40	40,000	
10,000, at $30	300,000	
20,000, at $20	400,000	
5,000, at $10	50,000	
5,200, at $5	26,000	
		$1,876,000
Clearing and burning 12,000 acres, at $15		180,000
Changes of highway, including fencing, 17.2 miles, at $2,000		34,400
Highway across reservoir at Castorland:		
4,000 linear feet bridge, at $33	132,000	
7,200 linear feet bridge, at $25	180,000	
109,000 cubic yards embankment, at 12 cents	13,080	
4,000 cubic yards riprap, at $1	4,000	
0.6 mile new road, at $2,000	1,200	
200 rods fencing, at $1	200	
		330,480
Highway across reservoir at Lowville:		
8,000 linear feet of bridge, at $33	264,000	
22,000 cubic yards embankment, at 12 cents	2,640	
1,400 cubic yards riprap, at $1	1,400	
3,800 linear feet of approaches, at $1	3,800	
100 rods fencing, at $1	100	
		271,940
Highway across reservoir at Glenfield:		
400 linear feet bridge, at $33	13,200	
2,400 linear feet bridge, at $25	60,000	
206,000 cubic yards embankment, at 12 cents	24,720	
13,200 cubic yards riprap, at $1	13,200	
860 rods fencing, at $1	860	
		111,980
Moving cemeteries		40,000
Changing location of 19 miles and raising 8.15 miles of R., W. and O. Div. of N. Y. C. and H. R. R. R. and Carthage and Adirondack R. R.:		
192 acres right of way, at $50	9,600	
90 acres clearing and grubbing, at $30	2,700	
850,000 cubic yards excavation of earth, at 25 cents	212,500	
175,000 cubic yards excavation of rock, at 80 cents	140,000	
68,000 cubic yards ballast, at 40 cents	27,200	
48,300 ties, at 50 cents	24,150	
2,100 tons steel rails (70 pounds per yard), at $35	73,500	
270,000 pounds angle bars, at 2¼ cents	6,075	
30,000 pounds bolts, at 2½ cents	750	
114,000 pounds spikes, at 2½ cents	2,850	
19 miles track laying, at $400	7,600	
36 miles fencing, at $500	18,000	

18 miles telegraph line, at $300		$5,400	
35,000 cubic yards riprap, at $1		35,000	
4 switches and stands, at $75		300	
2 stations and freight houses, at $2,200		4,400	
1 water tank		600	
Cast-iron pipe culverts, with end walls		6,000	
Bridge superstructures		52,000	
Bridge masonry		148,000	
14 road crossings, at $50		700	
Temporary track		13,265	
Moving Carthage station		1,000	
Total		791,590	
Credit present line:			
220 acres right of way, at $30	$6,600		
2,100 tons rails, at $20	42,000		
48,300 ties, at 30 cents	14,490		
750,000 pounds bridges, at 3 cents	22,500		
2,500 cubic yards masonry, at $2	5,000		
2 stations, at $500	1,000		
		91,590	
Net cost of changing railroad			$700,000
Dam No. 1, at Carthage:			
Clearing site of dam, including removal of buildings		5,000	
Bailing and draining, including coffer dams		44,467	
3,400 cubic yards surface stripping, at 12 cents		408	
56,200 cubic yards excavation of earth, at 20 cents		11,240	
36,500 cubic yards foundation excavation of rock, at $1.50		54,750	
4,300 cubic yards foundation excavation of hardpan, at 75 cents		3,225	
83,000 cubic yards rubble masonry in backing and core walls, at $4		332,000	
9,000 cubic yards concrete, at $5		45,000	
18,600 cubic yards granite masonry in spillway and discharge tunnels, at $15		279,500	
19,500 cubic yards coursed rubble-facing masonry, at $7		136,500	
740 cubic yards granite coping on spillway, at $25		18,500	
720 cubic yards coping on dam and protection walls, at $15		10,800	
1,600 cubic yards broken-stone lining, at $1.50		2,400	
1,300 cubic yards soiling, at 50 cents		650	
28,000 cubic yards embankment, at 25 cents		7,000	
650 cubic yards puddle, at $1		650	
4,800 square yards slope paving, at 70 cents		3,360	
3,900 square yards sodding, at 20 cents		780	
85,000 feet B. M. pine timber, at $30 per M		2,550	
30,000 pounds steel rods, bolts, etc., at 7 cents		2,100	
22,000 pounds 12-inch cast-iron pipe, laid, at 2 cents		440	
4,000 linear feet holes for dowels, at 10 cents		400	
1,000 linear feet railing, at $1		1,000	
4 steel discharge tunnel headings with sluice gates, at $2,500		10,000	
8 12-inch double gates and stands, complete, at $60		480	
1 gate-house superstructure, complete		1,000	
1 turbine and pump for operating gates		1,000	
			975,200

Dam No. 1 A:		
½ acre clearing and grubbing, at $40	$20.00	
1 bailing and draining	67.00	
400 cubic yards surface stripping, at 12 cents	48.00	
500 cubic yards excavation of earth, at 20 cents	100.00	
160 cubic yards foundation excavation of hardpan, at 75 cents	120.00	
240 cubic yards core-wall masonry, at $4	960.00	
125 cubic yards broken-stone lining, at $1.50	187.50	
100 cubic yards soiling, at 50 cents	50.00	
2,700 cubic yards embankment, at 25 cents	675.00	
50 cubic yards puddle, at $1	50.00	
375 square yards slope paving, at 70 cents	262.50	
300 square yards sodding, at 20 cents	60.00	
		$2,600
Dam No. 1 B:		
1 acre clearing and grubbing	40.00	
1 bailing and draining	122.00	
1,400 cubic yards surface stripping, at 12 cents	168.00	
350 cubic yards earth excavation, at 20 cents	70.00	
500 cubic yards foundation excavation of hardpan, at 75 cents	375.00	
1,100 cubic yards core-wall masonry, at $4	4,400.00	
940 cubic yards broken-stone lining, at $1.50	1,410.00	
800 cubic yards soiling, at 50 cents	400.00	
10,500 cubic yards embankment, at 25 cents	2,625.00	
250 cubic yards puddle, at $1	250.00	
2,800 square yards slope paving, at 70 cents	1,960.00	
2,400 square yards sodding, at 20 cents	480.00	
		12,300
Dam No. 1 C:		
1 clearing site of dam, including removal of buildings	1,000.00	
1 bailing and draining	870.00	
18,200 cubic yards excavation of earth, at 20 cents	3,640.00	
2,000 cubic yards foundation excavation of rock, at $1.50	3,000.00	
17,500 cubic yards backing in protection walls, at $4	70,000.00	
6,920 cubic yards facing in protection walls, at $7	48,440.00	
570 cubic yards coping on protection walls, at $15	8,550.00	
68,000 cubic yards embankment, at 25 cents	17,000.00	
3,500 linear feet gas-pipe railing, at $1	3,500.00	
		156,000
Dam No. 1 D:		
1 bailing and draining	394.00	
1,000 cubic yards surface stripping, at 12 cents	120.00	
18,200 cubic yards excavation of earth, at 20 cents	3,640.00	
320 cubic yards foundation excavation of rock, at $1.50	480.00	
3,400 cubic yards excavation of granite rock, at 80 cents	2,720.00	
1,100 cubic yards core-wall masonry, at $4	4,400.00	
470 cubic yards broken-stone lining, at $1	470.00	
390 cubic yards soiling, at 50 cents	195.00	
14,000 cubic yards embankment, at 25 cents	3,500.00	
210 cubic yards puddle, at $1	210.00	
1,410 square yards slope paving, at 70 cents	987.00	
1,170 square yards sodding, at 20 cents	234.00	
600 linear feet fencing, at 25 cents	150.00	
		17,500

Dam No. 1 E:		
1 bailing and draining	$447	
1,650 cubic yards surface stripping, at 12 cents	198	
1,050 cubic yards excavation of earth, at 20 cents	210	
160 cubic yards foundation excavation of rock, at $1.50	240	
600 cubic yards foundation excavation of hardpan, at 75 cents	450	
1,550 cubic yards core-wall masonry, at $4	6,200	
650 cubic yards broken-stone lining, at $1	650	
550 cubic yards soiling, at 50 cents	225	
15,000 cubic yards embankment, at 25 cents	3,750	
160 cubic yards puddle, at $1	160	
2,000 square yards slope paving, at 70 cents	1,400	
1,600 square yards sodding, at 20 cents	320	
1,000 linear feet fencing, at 25 cents	250	
		$14,500
Dam No. 1 F:		
3 acres clearing and grubbing, at $40	120	
1 bailing and draining	592	
3,400 cubic yards surface stripping, at 12 cents	408	
10,000 cubic yards excavation of earth, at 20 cents	2,000	
2,200 cubic yards foundation excavation of hardpan, at 75 cents	1,650	
3,400 cubic yards core-wall masonry, at $4	13,600	
1,900 cubic yards broken-stone lining, at $1.50	2,850	
1,400 cubic yards soiling, at 50 cents	700	
53,000 cubic yards embankment, at 25 cents	13,250	
500 cubic yards puddle, at $1	500	
5,700 square yards slope paving, at 70 cents	3,990	
4,200 square yards sodding, at 20 cents	840	
		40,500
Dam No. 1 G:		
3 acres clearing and grubbing, at $40	120	
1 bailing and draining	505	
3,500 cubic yards surface stripping, at 12 cents	420	
7,500 cubic yards excavation of earth, at 20 cents	1,500	
2,300 cubic yards foundation excavation of hardpan, at 75 cents	1,725	
3,400 cubic yards core-wall masonry, at $4	13,600	
1,800 cubic yards broken-stone lining, at $1	1,800	
1,500 cubic yards soiling, at 50 cents	750	
45,000 cubic yards embankment, at 25 cents	11,250	
450 cubic yards puddle, at $1	450	
5,400 square yards slope paving, at 70 cents	3,780	
4,500 square yards sodding, at 20 cents	900	
		36,800
Damage to water powers in valley above Carthage		900,000
Drain at West Carthage, 4,000 linear feet 24-inch sewer pipe, laid, at $3		12,000
Total cost of Black River reservoir		5,712,200

SALMON RIVER RESERVOIR.

Right of way:		
100 acres of land, at $300 (village of Redfield)	$30,000	
8,900 acres of land, at $30	267,000	
		$297,000
Clearing and burning 2,500 acres, at $15		37,500
Changes of highway, including fencing, 6 miles, at $3,000		18,000

Highway across reservoir at Redfield:		
1,200 linear feet bridge, at $30	$36,000	
120,000 cubic yards embankment, at 12 cents	14,400	
25,200 cubic yards riprap, at $1	25,200	
		$75,600
Bridge below dam at Stillwater		9,000
Dam No. 73:		
5 acres clearing and grubbing, at $40	200	
1 bailing and draining	5,360	
2,500 cubic yards surface stripping, at 12 cents	300	
5,000 cubic yards excavation of earth, at 20 cents	1,000	
22,000 cubic yards foundation excavation of hardpan, at 75 cents	16,500	
18,500 cubic yards foundation excavation of rock, at $1.50	27,750	
7,300 cubic yards granite spillway and arch masonry, at $15	109,500	
8,000 cubic yards facing masonry, at $7	56,000	
45,000 cubic yards rubble backing and core-wall masonry, at $5	225,000	
300 cubic yards spillway coping, at $25	7,500	
160 cubic yards coping on dam and wing walls, at $15	2,400	
4,000 cubic yards concrete, at $6	24,000	
1,000 cubic yards puddle, at $1	1,000	
1,700 cubic yards broken-stone lining, at $1.50	2,550	
1,000 cubic yards soiling, at 50 cents	500	
30,000 cubic yards embankment, at 25 cents	7,500	
5,000 square yards slope paving, at 70 cents	3,500	
3,000 square yards sodding, at 20 cents	600	
1,600 linear feet holes for dowels, at 10 cents	160	
325 linear feet 2¼-inch gate stems, with couplings, at 60 cents	195	
3,000 feet B. M. oak timber, at $40	120	
20,000 pounds 60-inch steel pipe, at 7 cents	1,400	
6,000 pounds 6-inch cast-iron pipe, at 2 cents	120	
12,000 pounds steel rods, bolts, etc, at 7 cents	840	
3 60-inch double gates, at $1,200	3,600	
4 6-inch double gates, at $10	40	
2 72-inch flume gates, at $700	1,400	
5 gate stands, at $25	125	
4 gate stands, at $10	40	
1 gatehouse superstructure, complete	800	
		500,000
Dam No. 74:		
1 acre clearing and grubbing	40	
1 bailing and draining	406	
700 cubic yards surface stripping, at 12 cents	84	
300 cubic yards excavation of earth, at 20 cents	60	
500 cubic yards foundation excavation of hardpan, at 75 cents	375	
1,200 cubic yards core-wall masonry, at $5	6,000	
500 cubic yards puddle, at $1	500	
530 cubic yards broken-stone lining, at $1.50	795	
450 cubic yards soiling, at 50 cents	225	
18,500 cubic yards embankment, at 25 cents	4,625	
1,600 square yards slope paving, at 70 cents	1,120	
1,350 square yards sodding, at 20 cents	270	
		14,500

Dam No. 75:		
2 acres clearing and grubbing, at $40	$80	
1 bailing and draining	506	
3,200 cubic yards surface stripping, at 12 cents	384	
1,000 cubic yards excavation of earth, at 20 cents	200	
2,000 cubic yards foundation excavation of hardpan, at 75 cents	1,500	
4,200 cubic yards core wall masonry, at $5	21,000	
2,000 cubic yards puddle, at $1	2,000	
2.900 cubic yards broken-stone lining, at $1.50	4,350	
2.400 cubic yards soiling, at 50 cents	1.200	
49,000 cubic yards embankment, at 25 cents	12,250	
8.700 square yards slope paving, at 70 cents	6,090	
7,200 square yards sodding, at 20 cents	1,440	
		$51,000
Dam No. 76:		
10 acres clearing and grubbing, at $40	400	
1 bailing and draining	1,550	
15,000 cubic yards surface stripping, at 12 cents	1,800	
3,000 cubic yards excavation of earth, at 20 cents	600	
7.000 cubic yards foundation excavation of hardpan, at 75 cents	5,250	
27,480 cubic yards core wall masonry, at $5	137,400	
10.000 cubic yards puddle, at $1	10,000	
14,500 cubic yards broken-stone lining, at $1.50	21,750	
12.000 cubic yards soiling, at 50 cents	6.000	
500.000 cubic yards embankment, at 25 cents	125.000	
43,500 square yards paving, at 70 cents	30,450	
36,000 square yards sodding, at 20 cents	7,200	
		347,400
Total cost of Salmon River reservoir		1,350,000

BLACK RIVER FEEDER.

Right of way:		
Acres—		
1,000, at $100	$100,000	
1.000, at $75	75,000	
2,000, at $50	100.000	
1,000, at $40	40.000	
3,000, at $25	75,000	
1,000, at $10	10,000	
		400,000
Clearing and burning 930 acres of land, at $15		13,950
Clearing and grubbing 220 acres of land, at $40		8.800
Excavation of earth, 13,750,000 cubic yards, at 20 cents		2,750,000
Excavation of hardpan, 1,180,000 cubic yards, at 35 cents		413,000
Excavation of shale rock, 430,000 cubic yards, at 55 cents		236,500
Excavation of sandstone rock, 120,000 cubic yards, at 65 cents		78,000
Excavation of limestone rock, 1,950,000 cubic yards, at 65 cents		1,267,500
Excavation of rock in tunnel, 116,000 cubic yards, at $3		348,000
Retaining-wall masonry, 41,000 cubic yards, at $5		205,000
Riprap, 300,000 cubic yards, at $1.10		330,000
Puddle, 200,000 cubic yards, at $1		200,000
Broken-stone lining, 4,000 cubic yards, at $1.50		6,000
Slope paving, 12,000 square yards, at 70 cents		8,400
Channeling, 3,150,000 square feet, at 10 cents		315,000

Fencing:		
133,000 linear feet stone wall, at 25 cents	$33,250	
336,000 linear feet wire fence, at 10 cents	33,600	
		$66,850
Telephone line, 100 miles, at $330		33,000
Farm crossings, 43, at $2,500		107,500
Dwellings for operation, 20, at $1,500		30,000
Guard gates, 9 sets, at $14,000		126,000
Dredges, 3 dredges, at $27,000		81,000
Shaft for tunnel		3,000
Ditching on side hills about cuts		5,000
Planting willows and special protection of slopes		25,000
Flood water channel above Camden:		
260,000 cubic yards excavation of earth, at 20 cents	$52,000	
2 highway bridges, at $5,000	10,000	
1 railroad bridge	8,000	
		70,000
Damage to water powers on streams tributary to feeder		40,000
Damage to water powers on Fish Creek		25,000
Railway bridges:		
1 bridge at Station 4328	$10,000	
1 bridge at Station 4537	10,000	
		20,000
Highway bridges:		
1 at each of the following stations—		
0+88	2,500	
12+40	2,500	
19+80	2,500	
59+40	4,000	
104+00	2,500	
215+70	2,500	
285+50	3,000	
296+00	2,500	
324+00	2,000	
354+20	2,000	
397+50	5,000	
502+30	2,500	
528+50	4,000	
557+00	5,000	
700+00	3,000	
722+50	2,500	
750+50	2,000	
783+20	2,000	
820+70	2,000	
850+50	2,000	
927+30	4,000	
1072–70	4,000	
1173+30	4,000	
1241+10	4,000	
Spillway of Dam No. 8	5,000	
1383+00	25,000	
1405+00	6,500	
1469+80	4,000	
1511+40	8,000	
1567+10	6,500	
1627+80	5,000	

Highway bridges—Continued.		
1 at each of the following stations—		
1649+00	$6,500	
1735+70	6,500	
1860+40	7,000	
1919+70	6,900	
1967+80	6,700	
2016+60	6,500	
2090+30	6,700	
2141+00	4,000	
2207+20	3,500	
2231+00	3,500	
2342+90	6,500	
2399+80	6,500	
2475+00	6,500	
2530+00	6,500	
2633+80	5,000	
2659+60	5,000	
2904+00	5,000	
4370+00	6,500	
4413+00	6,500	
4464+80	7,000	
4537+40	6,500	
4593+40	7,500	
4630+80	8,000	
4687+00	7,500	
4773+30	6,500	
4797+50	6,500	
		$293,300
Bridges on Fish Creek (openings to be enlarged):		
2 railway bridges, at $7,000	14,000	
10 highway bridges, at $4,000	40,000	
		54,000
Changes of highway:		
Linear feet of new highway at each of the following stations—		
Station 1, 300	1,200	
11, 200	400	
391, 1,300	2,600	
557, 11,400	11,400	
700, 800	800	
1310, 7,300	5,000	
1336, 5,200	3,100	
Crossing Dam No. 8, 3,000 linear feet new highway	5,000	
1390, 1,600	1,000	
1406, 1,800	1,100	
1470, 1,300	800	
1510, 900	600	
1568, 1,300	800	
1732, 2,000	1,200	
1852, 1,500	900	
1919, 800	800	
2016, 800	500	
2090, 1,000	600	
2390, 700	400	
2905, 1,000	600	

Changes of highway—Continued.		
Linear feet of new highway at each of the following stations.		
4370, 500	$300	
4396, 2,700	1,600	
4464, 3,200	3,200	
4535, 2,600	1,500	
4787, 4,000	2,400	
		$47,800
Dam No. 2, at West Carthage:		
1 bailing and draining, including cofferdams, etc	10,775	
7,850 cubic yards foundation excavation of rock, at $1.50	11,775	
3,000 cubic yards excavation of earth, at 20 cents	600	
1,000 cubic yards embankment, at 25 cents	250	
15,000 cubic yards masonry in dam and retaining wall, at $6	90,000	
440 cubic yards coping on dam and retaining wall, at $15	6,600	
		120,000
Dam No. 3:		
¼ acre clearing and grubbing, at $40	10	
1 bailing and draining	138	
225 cubic yards surface stripping, at 12 cents	27	
100 cubic yards excavation of earth, at 20 cents	20	
100 cubic yards foundation excavation of rock, at $1.50	150	
170 cubic yards core-wall masonry, at $4	680	
50 cubic yards puddle, at $1	50	
70 cubic yards broken-stone lining, at $1.50	105	
60 cubic yards soiling, at 50 cents	30	
800 cubic yards embankment, at 25 cents	200	
220 square yards slope paving, at 70 cents	154	
180 square yards sodding, at 20 cents	36	
		1,600
Dam No. 4, Townsend Brook:		
3 acres clearing and grubbing, at $40	120	
1 bailing and draining	754	
2,000 cubic yards surface stripping, at 12 cents	240	
20,000 cubic yards excavation of earth, at 20 cents	4,000	
3,700 cubic yards excavation of hardpan, at 35 cents	1,295	
1,240 cubic yards foundation excavation of hardpan, at 75 cents	930	
3,800 cubic yards core-wall masonry, at $4	15,200	
1,200 cubic yards protection-wall masonry, at $5	6,000	
1,910 cubic yards masonry in gatehouse and discharge culvert, at $6	11,460	
155 cubic yards coping on gatehouse, protection walls, and spillway, at $15	2,325	
4,500 cubic yards wasteway paving, at $4	18,000	
1,000 cubic yards broken-stone lining, at $1.50	1,500	
1,000 cubic yards puddle, at $1	1,000	
800 cubic yards soiling, at 50 cents	400	
25,000 cubic yards embankment, at 25 cents	6,250	
3,000 square yards slope paving, at 70 cents	2,100	
2,400 square yards sodding, at 20 cents	480	
8,000 pounds 60-inch steel pipe, at 7 cents	560	
800 pounds 6-inch cast-iron pipe, laid, at 2 cents	16	
3,000 pounds steel rods, bolts, etc., at 7 cents	210	
200 linear feet 2½-inch gate stems, at 60 cents	120	
60-inch double gate	1,200	

Dam No. 4, Townsend Brook—Continued.		
2 6-inch double gates, at $10	$20	
60-inch flume gate	400	
2 gate stands, at $25	50	
2 gate stands, at $10	20	
1 gatehouse superstructure	800	
bridge to gatehouse	250	
		$75,700
Dam No. 5: Estimate for this dam is included in estimate of feeder line, Station 360+50 to Station 387+30.		
Dam No. 6, Rutland Hollow Creek:		
4 acres clearing and grubbing, at $40	160	
1 bailing and draining	1,152	
5,600 cubic yards surface stripping, at 12 cents	672	
1,600 cubic yards excavation of earth, at 20 cents	320	
1,820 cubic yards foundation excavation of rock, at $1.50	2,730	
260 cubic yards foundation excavation of hardpan, at 75 cents	195	
8,840 cubic yards core-wall masonry, at $4	35,360	
1,910 cubic yards masonry in gatehouse and discharge tunnel, at $6	11,460	
300 cubic yards masonry in spillway, at $5	1,500	
46 cubic yards coping on gatehouse, spillway, etc., at $15	690	
2,100 cubic yards puddle, at $1	2,100	
3,150 cubic yards broken-stone lining, at $1.50	4,725	
2,650 cubic yards soiling, at 50 cents	1,325	
115,000 cubic yards embankment, at 25 cents	28,750	
9,450 square yards slope paving, at 70 cents	6,615	
8,000 square yards sodding, at 20 cents	1,600	
8,000 pounds 60-inch steel pipe, at 7 cents	560	
5,000 pounds steel rods, bolts, etc., at 7 cents	350	
800 pounds 6-inch cast-iron pipe, laid, at 2 cents	16	
100 linear feet holes for dowels, at 10 cents	10	
200 linear feet 2¼-inch steel gate stems, at 60 cents	120	
60-inch double gate	1,200	
2 6-inch double gates, at $10	20	
1 60-inch flume gate	400	
2 gate stands, at $25	50	
2 gate stands, at $10	20	
1 gatehouse superstructure	800	
bridge to gatehouse	250	
		103,150
Dam No. 7:		
2 acres clearing and grubbing, at $40	80	
1 bailing and draining	115	
1,500 cubic yards surface stripping, at 12 cents	180	
6,600 cubic yards excavation of earth, at 20 cents	1,320	
1,100 cubic yards foundation excavation of hardpan, at 75 cents	825	
3,450 cubic yards core-wall masonry, at $4	13,800	
1,050 cubic yards puddle, at $1	1,050	
700 cubic yards broken stone lining, at $1.50	1,050	
670 cubic yards soiling, at 50 cents	335	
21,500 cubic yards embankment, at 25 cents	5,375	
2,100 square yards slope paving, at 70 cents	1,470	
2,000 square yards sodding, at 20 cents	400	
		26,000

Dam No. 8, North Branch Sandy Creek:		
2 acres clearing and grubbing, at $40	$80	
1 bailing and draining	14,872	
15,250 cubic yards surface stripping, at 12 cents	1,830	
116,000 cubic yards excavation of earth, at 20 cents	23,200	
3,700 cubic yards excavation of limestone rock, at 65 cents	2,405	
2,260 cubic yards foundation excavation of hardpan, at 75 cents	1,695	
4,700 cubic yards foundation excavation of shale rock, at $1	4,700	
600 cubic yards foundation excavation of limestone rock, at $1.50	900	
34,600 cubic yards masonry in core walls, at $4	138,400	
4,070 cubic yards masonry in spillway, and protection walls, at $5	20,350	
450 cubic yards coping on piers, spillway, and protection walls, at $15	6,750	
4,500 cubic yards wasteway paving, at $4	18,000	
8,250 cubic yards broken stone lining, at $1	8,250	
9,150 cubic yards puddle, at $1	9,150	
6,850 cubic yards soiling, at 50 cents	3,425	
312,000 cubic yards embankment, at 25 cents	78,000	
1,900 cubic yards masonry in gatehouse and discharge culvert, at $6	11,400	
25,000 square yards paving, at 70 cents	17,500	
20,500 square yards sodding, at 20 cents	4,100	
12,000 feet B. M. pine timber, at $30 per M	360	
12,000 feet B. M. oak timber, at $40 per M	480	
35,000 pounds steel I-beams, at 5 cents	1,750	
8,000 pounds 60-inch steel pipe, at 7 cents	560	
6,500 pounds steel rods, bolts, etc., at 7 cents	455	
800 pounds 6-inch cast-iron pipe, laid, at 2 cents	16	
620 linear feet holes for dowels, at 10 cents	62	
600 linear feet 2½-inch steel shafting and gate stems, at 60 cents	360	
31 sets operating mechanism for spillway sluices, at $100	3,100	
60-inch double gate	1,200	
2 6-inch double gates, at $10	20	
60-inch flume gate	400	
2 gate stands, at $25	50	
2 gate stands, at $10	20	
1 gatehouse superstructure	800	
turbine, with gearing and shafting	600	
		$375,240
Dam No. 9, South Branch, Sandy Creek:		
7 acres clearing and grubbing, at $40	280	
1 bailing and draining	2,600	
166,000 cubic yards excavation of earth, at 20 cents	33,200	
11,000 cubic yards foundation excavation of shale rock, at $1	11,000	
7,500 cubic yards of rubble masonry backing, at $4	30,000	
10,000 cubic yards face masonry, at $7	70,000	
2,000 cubic yards protection-wall masonry, at $5	10,000	
4,500 cubic yards concrete, at $5	22,500	
460 cubic yards coping on dam, spillway, and protection walls, at $15	6,900	

Dam No. 9, South Branch, Sandy Creek—Continued.		
1,000 cubic yards embankment, at 25 cents	$250	
9,000 feet B. M. pine timber, at $30 per M	270	
8,000 feet B. M. oak timber, at $40 per M	320	
22,000 pounds steel I-beams, at 5 cents	1,100	
8,000 pounds steel rods, bolts, etc., at 7 cents	560	
8,000 pounds 60-inch steel pipe, at 7 cents	560	
4,000 pounds 6-inch cast-iron pipe, laid, at 2 cents	80	
500 linear feet holes for dowels, at 10 cents	50	
500 linear feet 2¼-inch steel shafting and gate stems, at 60 cents	300	
19 sets operating mechanism for spillway sluices, at $100	1,900	
2 60-inch double gates, at $1,200	2,400	
4 6-inch double gates, at $10	40	
4 60-inch flume gates, at $400	1,600	
6 gate stands, at $25	150	
4 gate stands, at $10	40	
1 gatehouse superstructure	800	
turbine, with shafting and gearing	600	
		$197,500
Dam No. 10:		
1 acre clearing and grubbing	40	
1 bailing and draining	148	
650 cubic yards surface stripping, at 12 cents	78	
520 cubic yards excavation of earth, at 20 cents	104	
300 cubic yards foundation excavation of hardpan, at 75 cents	225	
1,000 cubic yards core-wall masonry, at $4	4,000	
300 cubic yards broken stone lining, at $1.50	450	
250 cubic yards soiling, at 50 cents	125	
350 cubic yards puddle, at $1	350	
6,000 cubic yards embankment, at 25 cents	1,500	
900 square yards slope paving, at 70 cents	630	
750 square yards sodding, at 20 cents	150	
		7,800
Dam No. 11, Deer Creek:		
2 acres clearing and grubbing, at $40	80	
1 bailing and draining	2,308	
56,300 cubic yards excavation of earth, at 20 cents	11,260	
12,000 cubic yards excavation of shale rock, at 55 cents	6,600	
12,000 cubic yards foundation excavation, shale rock, at $1	12,000	
9,300 cubic yards rubble backing and spillway masonry, at $4	37,200	
1,000 cubic yards protection-wall masonry, at $5	5,000	
9,700 cubic yards face masonry, at $7	67,900	
5,500 cubic yards concrete, at $5	27,500	
430 cubic yards coping on dam and spillway, at $15	6,450	
8,000 feet B. M. pine timber, at $30 per M	240	
6,000 feet B. M. oak timber, at $40 per M	240	
420 linear feet holes for dowels, at 10 cents	42	
500 linear feet 2¼-inch steel shafting and gate stems, at 60 cents	300	
8,000 pounds 60-inch steel pipe, at 7 cents	560	
15,000 pounds steel I-beams, at 5 cents	750	
4,000 pounds 6-inch cast-iron pipe, at 2 cents	80	

Dam No. 11, Deer Creek—Continued.		
8,000 pounds steel rods, bolts, etc., at 7 cents	$560	
13 sets operating mechanism for spillway sluices, at $100	1,300	
2 60-inch double gates, at $1,200	2,400	
4 6-inch double gates, at $10	40	
4 60-inch flume gates, at $400	1,600	
6 gate stands, at $25	150	
4 gate stands, at $10	40	
1 gatehouse superstructure	800	
turbine, with gearing and shafting	600	
		$186,000
Dam No. 12, Lorraine Brook:		
½ acre clearing and grubbing, at $40	20	
1 bailing and draining	1,170	
2,300 cubic yards excavation of earth, at 20 cents	460	
2,500 cubic yards foundation excavation of shale rock, at $1	2,500	
1,750 cubic yards rubble backing masonry, at $4	7,000	
2,850 cubic yards face masonry, at $7	19,950	
730 cubic yards concrete, at $5	3,650	
130 cubic yards coping on dam, at $15	1,950	
400 cubic yards embankment, at 25 cents	100	
		36,800
Dam No. 13:		
1 acre clearing and grubbing	40	
1 bailing and draining	135	
700 cubic yards surface stripping, at 12 cents	84	
300 cubic yards excavation of earth, at 20 cents	60	
450 cubic yards core-wall masonry, at $4	1,800	
250 cubic yards broken-stone lining, at $1.50	375	
210 cubic yards soiling, at 50 cents	105	
4,000 cubic-yards embankment, at 25 cents	1,000	
150 cubic yards puddle, at $1	150	
750 square yards slope paving, at 70 cents	525	
630 square yards sodding, at 20 cents	126	
		4,400
Dam No. 14:		
¼ acre clearing and grubbing, at $40	10	
1 bailing and draining	80	
150 cubic yards surface stripping, at 12 cents	18	
150 cubic yards excavation of earth, at 20 cents	30	
135 cubic yards core-wall masonry, at $4	540	
50 cubic yards broken-stone lining, at $1.50	75	
42 cubic yards soiling, at 50 cents	21	
520 cubic yards embankment, at 25 cents	130	
65 cubic yards puddle, at $1	65	
150 square yards slope paving, at 70 cents	105	
130 square yards sodding, at 20 cents	26	
		1,100
Dam No. 15, Bear Creek:		
3 acres clearing and grubbing, at $40	120	
1 bailing and draining	729	
3,400 cubic yards surface stripping, at 12 cents	408	
9,650 cubic yards excavation of earth, at 20 cents	1,930	
1,350 cubic yards foundation excavation of shale rock, at $1	1,350	
5,000 cubic yards core-wall masonry, at $4	20,000	
1,700 cubic yards broken-stone lining, at $1.50	2,550	

Dam No. 15, Bear Creek—Continued.		
1,450 cubic yards soiling, at 50 cents	$725	
37,000 cubic yards embankment, at 25 cents	9,250	
2,000 cubic yards puddle, at $1	2,000	
5,100 square yards slope paving, at 70 cents	3,570	
4,350 square yards sodding, at 20 cents	870	
		$43,502
Dam No. 16:		
1 acre clearing and grubbing	40	
1 bailing and draining	439	
1,300 cubic yards surface stripping, at 12 cents	156	
2,200 cubic yards excavation of earth, at 20 cents	440	
400 cubic yards foundation excavation of hardpan, at 75 cents	300	
1,700 cubic yards core-wall masonry, at $4	6,800	
650 cubic yards broken-stone lining, at $1.50	975	
530 cubic yards soiling, at 50 cents	265	
16,000 cubic yards embankment, at 25 cents	4,000	
700 cubic yards puddle, at $1	700	
1,950 square yards slope paving, at 70 cents	1,365	
1,600 square yards sodding, at 20 cents	320	
		15,800
Dam No. 17, Skinner Creek:		
2 acres clearing and grubbing, at $40	80	
1 bailing and draining	689	
2,150 cubic yards surface stripping, at 12 cents	258	
5,400 cubic yards excavation of earth, at 20 cents	1,080	
470 cubic yards foundation excavation of shale rock, at $1	470	
3,000 cubic yards core-wall masonry, at $4	$12,000	
1,050 cubic yards gatehouse and discharge-culvert masonry, at $6	6,300	
200 cubic yards protection-wall masonry, at $5	1,000	
30 cubic yards coping on gatehouse and protection walls, at $15	450	
1,225 cubic yards puddle, at $1	1,225	
25,600 cubic yards embankment, at 25 cents	6,400	
1,100 cubic yards broken-stone lining, at $1.50	1,650	
900 cubic yards soiling, at 50 cents	450	
3,300 square yards slope paving, at 70 cents	2,310	
2,700 square yards sodding, at 20 cents	540	
8,000 pounds 60-inch steel pipe, at 7 cents	560	
3,000 pounds steel rods, bolts, etc., at 7 cents	210	
800 pounds 6-inch cast-iron pipe, at 2 cents	16	
120 linear feet gate stems and couplings, at 60 cents	72	
60-inch double gate	1,200	
2 6-inch double gates, at $10	20	
60-inch flumegate	400	
2 gate stands, at $25	50	
2 gate stands, at $10	20	
1 gatehouse superstructure	800	
bridge to gatehouse	250	
		38,500
Dam No. 18:		
2 acres clearing and grubbing, at $40	80	
1 bailing and draining	492	
2,650 cubic yards surface stripping, at 12 cents	318	

Dam No. 18—Continued.		
1,500 cubic yards excavation of earth, at 20 cents	$300	
720 cubic yards foundation excavation of shale rock, at $1	720	
3,350 cubic yards core-wall masonry, at $4	13,400	
1,500 cubic yards puddle, at $1	1,500	
42,000 cubic yards embankment, at 25 cents	10,500	
1,300 cubic yards broken-stone lining, at $1.50	1,950	
1,100 cubic yards soiling at 50 cents	550	
3,900 square yards slope paving, at 70 cents	2,730	
3,300 square yards sodding, at 20 cents	660	
		$33,200
Dam No. 19:		
2 acres clearing and grubbing, at $40	80	
1 bailing and draining	379	
2,200 cubic yards surface stripping, at 12 cents	264	
1,100 cubic yards excavation of earth, at 20 cents	220	
640 cubic yards foundation excavation of hardpan, at 75 cents	480	
2,750 cubic yards core-wall masonry, at $4	11,000	
24,000 cubic yards embankment, at 25 cents	6,000	
1,120 cubic yards broken-stone lining, at $1.50	1,680	
930 cubic yards soiling at 50 cents	465	
1,000 cubic yards puddle at $1	1,000	
3,360 square yards slope paving, at 70 cents	2,352	
2,800 square yards sodding, at 20 cents	560	
		24,480
Dam No. 20, South Branch Skinner Creek:		
3 acres clearing and grubbing at $40	120	
1 bailing and draining	478	
3,350 cubic yards surface stripping at 12 cents	402	
1,400 cubic yards excavation of earth, at 20 cents	280	
960 cubic yards foundation excavation of hardpan, at 75 cents	720	
4,000 cubic yards core-wall masonry, at $4	16,000	
1,420 cubic yards puddle, at $1	1,420	
37,000 cubic yards embankment, at 25 cents	9,250	
1,730 cubic yards broken-stone lining, at $1.50	2,595	
1,450 cubic yards soiling at 50 cents	725	
5,200 square yards slope paving, at 70 cents	3,640	
4,350 square yards sodding, at 20 cents	870	
		36,500
Dam No. 21:		
3 acres clearing and grubbing, at $40	120	
1 bailing and draining	726	
4,200 cubic yards surface stripping, at 12 cents	504	
4,300 cubic yards excavation of earth, at 20 cents	860	
740 cubic yards foundation excavation of hardpan, at 75 cents	555	
4,750 cubic yards core-wall masonry, at $4	19,000	
2,000 cubic yards puddle, at $1	2,000	
2,250 cubic yards broken-stone lining, at $1.50	3,375	
76,500 cubic yards embankment, at 25 cents	19,125	
1,850 cubic yards soiling at 50 cents	925	
6,700 square yards slope paving at 70 cents	4,690	
5,600 square yards sodding, at 20 cents	1,120	
		53,000

Dam No. 22:		
1 acre clearing and grubbing	$40	
1 bailing and draining	239	
950 cubic yards surface stripping, at 12 cents	114	
950 cubic yards excavation of earth, at 20 cents	190	
400 cubic yards foundation excavation of hardpan, at 75 cents	300	
1,160 cubic yards core-wall masonry, at $4	4,640	
400 cubic yards puddle, at $1	400	
450 cubic yards broken-stone lining, at $1.50	675	
370 cubic yards soiling, at 50 cents	185	
5,400 cubic yards embankment, at 25 cents	1,350	
1,350 square yards slope paving, at 70 cents	945	
1,110 square yards sodding, at 20 cents	222	
		$9,300
Dam No. 23:		
1 acre clearing and grubbing	40	
1 bailing and draining	812	
1,100 cubic yards surface stripping, at 12 cents	132	
2,250 cubic yards excavation of earth, at 20 cents	450	
400 cubic yards foundation excavation of hardpan, at 75 cents	300	
1,500 cubic yards core-wall masonry, at $4	6,000	
550 cubic yards puddle, at $1	550	
460 cubic yards broken stone lining, at $1	460	
400 cubic yards soiling, at 50 cents	200	
10,200 cubic yards embankment, at 25 cents	2,550	
1,380 square yards slope paving, at 70 cents	966	
1,200 square yards sodding, at 20 cents	240	
		12,200
Dam No. 24, Lindsay Creek:		
1 acre clearing and grubbing	40	
1 bailing and draining	252	
900 cubic yards surface stripping, at 12 cents	108	
400 cubic yards excavation of earth, at 20 cents	80	
420 cubic yards foundation excavation of shale rock, at $1	420	
1,200 cubic yards core-wall masonry, at $4	4,800	
350 cubic yards broken-stone lining, at $1.50	525	
310 cubic yards puddle, at $1	310	
300 cubic yards soiling, at 50 cents	150	
4,400 cubic yards embankment, at 25 cents	1,100	
1,050 square yards slope paving, at 70 cents	735	
900 square yards sodding, at 20 cents	180	
		8,700
Dam No. 25:		
1 acre clearing and grubbing	40	
1 bailing and draining	264	
1,500 cubic yards surface stripping, at 12 cents	180	
5,500 cubic yards excavation of earth, at 20 cents	1,100	
540 cubic yards foundation excavation of hardpan, at 75 cents	405	
2,275 cubic yards core-wall masonry, at $4	9,100	
940 cubic yards puddle, at $1	940	
750 cubic yards broken-stone lining, at $1.50	1,125	
610 cubic yards soiling, at 50 cents	305	

Dam No. 25—Continued.		
20,800 cubic yards embankment, at 25 cents	$5,200	
2,250 square yards slope paving, at 70 cents	1,575	
1,830 square yards sodding, at 20 cents	366	$20,600
Dam No. 26:		
1 acre clearing and grubbing	40	
1 bailing and draining	265	
900 cubic yards surface stripping, at 12 cents	108	
500 cubic yards excavation of earth, at 20 cents	100	
360 cubic yards foundation excavation of shale rock, at $1	360	
1,100 cubic yards core-wall masonry, at $4	4,400	
370 cubic yards puddle, at $1	370	
420 cubic yards broken-stone lining, at $1.50	630	
350 cubic yards soiling, at 50 cents	175	
7,240 cubic yards embankment, at 25 cents	1,810	
1,260 square yards slope paving, at 70 cents	882	
1,050 square yards sodding, at 20 cents	210	9,350
Dam No. 27:		
2 acres clearing and grubbing, at $40	80	
1 bailing and draining	398	
1,900 cubic yards surface stripping, at 12 cents	228	
650 cubic yards excavation of earth, at 20 cents	130	
470 cubic yards foundation excavation of shale rock, at $1	470	
1,950 cubic yards core-wall masonry, at $4	7,800	
740 cubic yards puddle, at $1	740	
900 cubic yards broken-stone lining, at $1.50	1,350	
18,400 cubic yards embankment, at 25 cents	4,600	
740 cubic yards soiling, at 50 cents	370	
2,700 square yards slope paving, at 70 cents	1,890	
2,220 square yards sodding, at 20 cents	444	18,500
Dam No. 28:		
1 acre clearing and grubbing	40	
1 bailing and draining	127	
800 cubic yards surface stripping, at 12 cents	96	
520 cubic yards excavation of earth, at 20 cents	104	
400 cubic yards foundation excavation of shale rock, at $1	400	
970 cubic yards core-wall masonry, at $4	3,880	
300 cubic yards puddle, at $1	300	
330 cubic yards broken-stone lining, at $1.50	495	
280 cubic yards soiling, at 50 cents	140	
4,200 cubic yards embankment, at 25 cents	1,050	
1,000 square yards paving, at 70 cents	700	
840 square yards sodding, at 20 cents	168	7,500
Dam No. 29, Little Sandy Creek:		
3 acres clearing and grubbing, at $40	120	
1 bailing and draining	1,335	
1,500 cubic yards surface stripping, at 12 cents	180	
50,000 cubic yards excavation of earth, at 20 cents	10,000	
2,300 cubic yards foundation excavation of shale rock, at $1	2,300	
1,500 cubic yards core-wall masonry, at $4	6,000	
1,720 cubic yards spillway and protection-wall masonry, at $5	8,600	

Dam No. 29, Little Sandy Creek—Continued.		
182 cubic yards spillway and protection-wall coping, at $15	$2,730	
3,500 cubic yards wasteway paving, at $4	14,000	
700 cubic yards broken-stone lining, at $1.50	1,050	
600 cubic yards soiling, at 50 cents	300	
15,000 cubic yards embankment, at 25 cents	3,750	
520 cubic yards puddle, at $1	520	
700 cubic yards concrete, at $5	3,500	
2,100 square yards slope paving, at 70 cents	1,470	
1,800 square yards sodding, at 20 cents	360	
5,000 feet B. M. pine timber, at $30 per M	150	
5,000 feet B. M. oak timber, at $40 per M	200	
400 linear feet holes for dowels, at 10 cents	40	
200 linear feet 2½-inch steel shafting, at 60 cents	120	
2,500 pounds steel rods, bolts, etc., at 7 cents	175	
15,000 pounds steel I-beams, at 5 cents	750	
13 sets operating mechanisms for spillway sluices, at $100	1,300	
turbine, with shafting and gearing	600	
		$59,550
Dam No. 30:		
1 acre clearing and grubbing	40	
1 bailing and draining	290	
1,250 cubic yards surface stripping, at 12 cents	150	
500 cubic yards excavation of earth, at 20 cents	100	
500 cubic yards foundation excavation of shale rock, at $1	500	
1,150 cubic yards core-wall masonry, at $4	4,600	
160 cubic yards puddle, at $1	160	
600 cubic yards broken-stone lining, at $1.50	900	
500 cubic yards soiling, at 50 cents	250	
9,000 cubic yards embankment, at 25 cents	2,250	
1,800 square yards slope paving, at 70 cents	1,260	
1,500 square yards sodding, at 20 cents	300	
		10,800
Dam No. 31:		
1 acre clearing and grubbing	40	
1 bailing and draining	294	
800 cubic yards surface stripping, at 12 cents	96	
700 cubic yards excavation of earth, at 20 cents	140	
500 cubic yards foundation excavation of shale rock, at $1	500	
1,050 cubic yards core-wall masonry, at $4	4,200	
300 cubic yards puddle, at $1	300	
300 cubic yards broken-stone lining, at $1.50	450	
250 cubic yards soiling, at 50 cents	125	
7,500 cubic yards embankment, at 25 cents	1,875	
900 square yards slope paving, at 70 cents	630	
750 square yards sodding, at 20 cents	150	
		8,800
Dam No. 32:		
1 acre clearing and grubbing	40	
1 bailing and draining	269	
1,250 cubic yards surface stripping, at 12 cents	150	
550 cubic yards excavation of earth, at 20 cents	110	
370 cubic yards foundation excavation of shale rock, at $1	370	
1,060 cubic yards core-wall masonry, at $4	4,240	

Dam No. 32—Continued.		
460 cubic yards puddle, at $1	$460	
560 cubic yards broken-stone lining, at $1.50	840	
450 cubic yards soiling, at 50 cents	225	
7,000 cubic yards embankment, at 25 cents	1,750	
1,680 square yards paving, at 70 cents	1,176	
1,350 square yards sodding, at 20 cents	270	
		$9,900
Dam No. 33:		
1 acre clearing and grubbing	40	
1 bailing and draining	376	
1,400 cubic yards surface stripping, at 12 cents	168	
900 cubic yards excavation of earth, at 20 cents	180	
500 cubic yards foundation excavation of shale rock, at $1	500	
1,270 cubic yards core-wall masonry, at $4	5,080	
530 cubic yards puddle, at $1	530	
570 cubic yards broken-stone lining, at $1.50	855	
460 cubic yards soiling, at 50 cents	230	
6,300 cubic yards embankment, at 25 cents	1,575	
1,700 square yards slope paving, at 70 cents	1,190	
1,380 square yards sodding, at 20 cents	276	
		11,000
Dam No. 34:		
1 acre clearing and grubbing	40	
1 bailing and draining	140	
450 cubic yards surface stripping, at 12 cents	54	
300 cubic yards excavation of earth, at 20 cents	60	
200 cubic yards foundation excavation of shale rock, at $1	200	
460 cubic yards core-wall masonry, at $4	1,840	
175 cubic yards puddle, at $1	175	
170 cubic yards broken-stone lining, at $1.50	255	
140 cubic yards soiling, at 50 cents	70	
2,100 cubic yards embankment, at 25 cents	525	
510 square yards slope paving, at 70 cents	357	
420 square yards sodding, at 20 cents	84	
		3,800
Dams Nos. 35 and 36:		
2 acres clearing and grubbing, at $40	80	
1 bailing and draining	249	
2,800 cubic yards surface stripping, at 12 cents	336	
3,000 cubic yards excavation of earth, at 20 cents	600	
2,800 cubic yards core-wall masonry, at $4	11,200	
1,100 cubic yards puddle, at $1	1,100	
1,150 cubic yards broken-stone lining, at $1.50	1,725	
950 cubic yards soiling, at 50 cents	475	
12,200 cubic yards embankment, at 25 cents	3,050	
3,450 square yards slope paving, at 70 cents	2,415	
2,850 square yards sodding, at 20 cents	570	
		21,800
Dam No. 37:		
½ acre clearing and grubbing, at $40	20	
1 bailing and draining	193	
600 cubic yards surface stripping, at 12 cents	72	
500 cubic yards excavation of earth, at 20 cents	100	
320 cubic yards foundation excavation of shale rock, at $1	320	
600 cubic yards core-wall masonry, at $4	2,400	

Dam No. 37—Continued.		
230 cubic yards puddle, at $1	$230	
230 cubic yards broken-stone lining, at $1.50	345	
190 cubic yards soiling at 50 cents	95	
2,500 cubic yards embankment, at 25 cents	625	
700 square yards slope paving, at 70 cents	490	
550 square yards sodding, at 20 cents	110	
		$5,000
Dam No. 38:		
½ acre clearing and grubbing, at $40	20	
1 bailing and draining	181	
525 cubic yards surface stripping, at 12 cents	63	
400 cubic yards excavation of earth, at 20 cents	80	
310 cubic yards foundation excavation of shale rock, at $1	310	
900 cubic yards core-wall masonry, at $4	3,600	
200 cubic yards puddle, at $	200	
200 cubic yards broken-stone lining, at $1.50	300	
160 cubic yards soiling at 50 cents	80	
2,200 cubic yards embankment, at 25 cents	550	
600 square yards slope paving, at 70 cents	420	
480 square yards sodding, at 20 cents	96	
		5,900
Dam No. 39:		
1 acre clearing and grubbing	40	
1 bailing and draining	263	
1,400 cubic yards surface stripping, at 12 cents	168	
4,200 cubic yards excavation of earth, at 20 cents	840	
520 cubic yards foundation excavation of shale rock, at $1	520	
700 cubic yards core-wall masonry, at $4	6,800	
800 cubic yards puddle, at $1	800	
570 cubic yards broken-stone lining, at $1.50	855	
470 cubic yards soiling at 50 cents	235	
8,800 cubic yards embankment, at 25 cents	2,200	
1,710 square yards slope paving, at 70 cents	1,197	
1,410 square yards sodding, at 20 cents	282	
		14,200
Dam No. 40, Trout Brook:		
1 acre clearing and grubbing	40	
1 bailing and draining	254	
1,100 cubic yards surface stripping, at 12 cents	132	
600 cubic yards excavation of earth, at 20 cents	120	
420 cubic yards foundation excavation of shale rock, at $1	420	
1,350 cubic yards core-wall masonry, at $4	5,400	
450 cubic yards puddle, at $1	450	
520 cubic yards broken-stone lining, at $1.50	780	
420 cubic yards soiling, at 50 cents	210	
9,000 cubic yards embankment, at 25 cents	2,250	
1,560 square yards slope paving, at 70 cents	1,092	
1,260 square yards sodding, at 20 cents	252	
		11,400
Dam No. 41:		
½ acre clearing and grubbing, at $40	20	
1 bailing and draining	290	
625 cubic yards surface stripping, at 12 cents	75	
2,400 cubic yards excavation of earth, at 20 cents	480	
400 cubic yards foundation excavation of shale rock, at $1	400	

Dam No. 41—Continued.		
1,100 cubic yards core-wall masonry, at $4	$4,400	
250 cubic yards broken-stone lining, at $1.50	375	
600 cubic yards soiling, at 50 cents	300	
370 cubic yards puddle, at $1	370	
3,700 cubic yards embankment, at 25 cents	925	
750 square yards slope paving, at 70 cents	525	
200 square yards sodding, at 20 cents	40	
		$8,200
Dam No. 42, South Branch of Trout Brook:		
2 acres clearing and grubbing, at $40	80	
1 bailing and draining	506	
1,150 cubic yards surface stripping, at 12 cents	138	
3,000 cubic yards excavation of earth, at 20 cents	600	
500 cubic yards foundation excavation of rock, at $1.50	750	
1,225 cubic yards core-wall masonry, at $4	4,900	
450 cubic yards gatehouse and discharge-culvert masonry, at $6	2,700	
15 cubic yards coping on gatehouse, at $15	225	
550 cubic yards puddle, at $1	550	
470 cubic yards broken-stone lining, at $1.50	705	
390 cubic yards soiling, at 50 cents	195	
8,000 cubic yards embankment, at 25 cents	2,000	
1,410 square yards slope paving, at 70 cents	987	
1,170 square yards soiling, at 20 cents	234	
8,000 pounds 60-inch steel pipe, at 7 cents	560	
800 pounds 6-inch cast-iron pipe, at 2 cents	16	
2,000 pounds steel rods, bolts, etc., at 7 cents	140	
40 linear feet gate stems and couplings, at 60 cents	24	
60-inch flume gate	400	
60-inch double gate	1,000	
2 6-inch double gates, at $10	20	
2 gate stands, at $25	50	
2 gate stands, at $10	20	
1 gatehouse superstructure	800	
bridge to gatehouse	150	
		17,750
Dam No. 43:		
1 acre clearing and grubbing	40	
800 cubic yards surface stripping, at 12 cents	96	
3,500 cubic yards embankment, at 25 cents	875	
486 cubic yards puddle, at $1	486	
330 cubic yards broken-stone lining, at $1.50	495	
280 cubic yards soiling, at 50 cents	140	
500 cubic yards excavation of earth, at 20 cents	100	
1,000 square yards slope paving, at 70 cents	700	
840 square yards sodding, at 20 cents	168	
		3,100
Dam No. 44:		
1 acre clearing and grubbing	40	
1 bailing and draining	221	
700 cubic yards surface stripping, at 12 cents	84	
2,000 cubic yards excavation of earth, at 20 cents	400	
280 cubic yards foundation excavation of hardpan, at 75 cents	210	

Dam No. 44—Continued.		
810 cubic yards core-wall masonry, at $4	$3,240	
400 cubic yards puddle, at $1	400	
300 cubic yards broken-stone lining, at $1.50	450	
250 cubic yards soiling, at 50 cents	125	
4,200 cubic yards embankment, at 25 cents	1,050	
900 square yards paving, at 70 cents	630	
750 square yards sodding, at 20 cents	150	
		$7,000
Dam No. 45, Orwell Brook:		
1 acre clearing and grubbing	40	
1 bailing and draining	262	
1,025 cubic yards surface stripping, at 12 cents	123	
3,200 cubic yards excavation of earth, at 20 cents	640	
500 cubic yards foundation excavation of hardpan, at 75 cents	375	
1,850 cubic yards core-wall masonry, at $4	7,400	
700 cubic yards puddle, at $1	700	
600 cubic yards broken-stone lining, at $1.50	900	
500 cubic yards soiling, at 50 cents	250	
9,000 cubic yards embankment, at 25 cents	2,250	
1,800 square yards slope paving, at 70 cents	1,260	
1,500 square yards sodding, at 20 cents	300	
		14,500
Dam No. 46:		
1 acre clearing and grubbing	40	
1 bailing and draining	233	
1,100 cubic yards surface stripping, at 12 cents	132	
1,200 cubic yards excavation of earth, at 20 cents	240	
900 cubic yards core-wall masonry, at $4	3,600	
500 cubic yards puddle, at $1	500	
400 cubic yards broken-stone lining, at $1.50	600	
330 cubic yards soiling, at 50 cents	165	
5,000 cubic yards embankment, at 25 cents	1,250	
1,200 square yards paving, at 70 cents	840	
1,000 square yards sodding, at 20 cents	200	
		7,800
Dam No. 47, Salmon River:		
5 acres clearing and grubbing, at $40	200	
1 bailing and draining	7,560	
10,000 cubic yards excavation of earth, at 20 cents	2,000	
70,000 cubic yards excavation of sandstone rock, at 65 cents	45,500	
25,000 cubic yards backing and core-wall masonry, at $5	125,000	
5,000 cubic yards face masonry, at $7	35,000	
7,200 cubic yards granite spillway masonry, at $15	108,000	
500 cubic yards granite coping on spillway, at $25	12,500	
200 cubic yards coping on dam and wing walls, at $15	3,000	
3,000 cubic yards concrete, at $5	15,000	
8,000 cubic yards embankment, at 25 cents	2,000	
400 cubic yards broken-stone lining, at $1.50	600	
1,200 square yards slope paving, at 70 cents	840	
800 linear feet holes for dowels, at 10 cents	80	
250 linear feet gate stems with couplings, at 60 cents	150	
5,000 feet B. M. oak timber, at $40 per M	200	
5,000 feet B. M. pine timber, at $30 per M	150	

Dam No. 47. Salmon River—Continued.		
24,000 pounds 72 and 36 inch steel pipe, at 7 cents	$1,680	
10,000 pounds steel rods, bolts, etc., at 7 cents	700	
4,000 pounds 6-inch cast-iron pipe, at 2 cents	80	
2 72-inch double gates, at $1,500	3,000	
36-inch double gate	350	
6 6-inch double gates	60	
2 72-inch flume gates, at $700	1,400	
36-inch flume gate	250	
4 gate stands, at $25	100	
2 gate stands, at $20	40	
6 gate stands, at $10	60	
1 gatehouse superstructure	1,000	
		$366,500
Dam No. 48: No dam required.		
Dam No. 49:		
½ acre clearing and grubbing, at $40	20	
1 bailing and draining	180	
500 cubic yards surface stripping, at 12 cents	60	
600 cubic yards excavation of earth, at 20 cents	120	
540 cubic yards core-wall masonry, at $5	2,700	
240 cubic yards puddle, at $1	240	
200 cubic yards broken-stone lining, at $1.50	300	
170 cubic yards soiling, at 50 cents	85	
3,500 cubic yards embankment, at 25 cents	875	
600 square yards slope paving, at 70 cents	420	
500 square yards sodding, at 20 cents	100	
		5,100
Dam No. 50. Beaver Dam Brook, to be a timber dam, to cost complete		1,000
Dam No. 51. Drop into Upper Kasoag Pond:		
2 acres clearing and grubbing, at $40	80	
1 bailing and draining	1,430	
1,000 cubic yards surface stripping, at 12 cents	120	
80,000 cubic yards excavation of earth, at 20 cents	16,000	
1,400 cubic yards core-wall masonry, at $5	7,000	
3,000 cubic yards spillway and protection-wall masonry, at $6	18,000	
200 cubic yards coping on spillway and protection walls, at $15	3,000	
700 cubic yards puddle, at $1	700	
1,650 cubic yards wasteway paving, at $4	6,600	
1,050 cubic yards broken-stone lining, at $1.50	1,575	
300 cubic yards soiling, at 50 cents	150	
7,000 cubic yards embankment, at 25 cents	1,750	
350 square yards slope paving, at 70 cents	245	
900 square yards sodding, at 20 cents	180	
300 linear feet holes for dowels, at 10 cents	30	
2,000 pounds steel rods, at 7 cents	140	
		57,000
Dam No. 52. Drop from Lower Kasoag Pond to Fish Creek:		
4 acres clearing and grubbing, at $40	160	
1 bailing and draining	1,020	
60,000 cubic yards excavation of earth, at 20 cents	12,000	
600 cubic yards rubble masonry, at $5	3,000	

Dam No. 52—Continued.		
4,000 cubic yards spillway and protection-wall masonry, at $6	$24,000	
300 cubic yards coping on spillway and protection walls, at $15	4,500	
400 cubic yards puddle, at $1	400	
10,400 cubic yards wasteway paving, at $4	41,600	
3,000 cubic yards embankment, at 25 cents	750	
300 linear feet holes for dowels, at 10 cents	30	
2,000 pounds steel rods, at 7 cents	140	
		$87,600
Dam No. 53, head of flood water channel above Camden:		
1 bailing and draining	1,870	
16,000 cubic yards excavation of earth, at 20 cents	3,200	
1,400 cubic yards spillway and protection-wall masonry, at $5	7,000	
170 cubic yards coping on spillway and protection walls, at $15	2,550	
300 cubic yards puddle, at $1	300	
2,000 cubic yards embankment, at 25 cents	500	
1,200 cubic yards wasteway paving, at $4	4,800	
8,000 feet B. M. pine timber, at $30 per M	240	
8,000 feet B. M. oak timber at $40 per M	320	
500 linear feet holes for dowels, at 10 cents	50	
400 linear feet 2¼-inch steel shafting, at 60 cents	240	
3,000 pounds steel rods, bolts, etc., at 7 cents	210	
22,400 pounds steel I-beams, at 5 cents	1,120	
20 sets operating mechanisms for spillway sluices, at $100	2,000	
1 turbine, with gearing and shafting, at $600	600	
		25,000
Dam No. 54, West Branch Fish Creek:		
4 acres clearing and grubbing, at $40	160	
1 bailing and draining	3,080	
500 cubic yards surface stripping, at 12 cents	60	
28,000 cubic yards excavation of earth, at 20 cents	5,600	
5,000 cubic yards rubble-masonry backing, at $5	25,000	
1,500 cubic yards faces masonry, at $7	10,500	
1,700 cubic yards granite spillway masonry, at $15	25,500	
750 cubic yards protection-wall masonry, at $6	4,500	
100 cubic yards coping on gatehouse and protection walls, at $15	1,500	
1,800 cubic yards wasteway paving, at $4	7,200	
4,000 cubic yards embankment, at 25 cents	1,000	
200 cubic yards puddle, at $1	200	
300 cubic yards broken-stone lining, at $1.50	450	
200 cubic yards soiling, at 50 cents	100	
900 square yards slope paving, at 70 cents	630	
600 square yards sodding, at 20 cents	120	
400 linear feet holes for dowels, at 10 cents	40	
10,000 feet B. M. oak timber, at $40 per M	400	
3,000 pounds steel rods and bolts, at 7 cents	210	
3 4 by 8 feet sluice gates, at $100	300	
3 lifting apparatus for sluice gates, at $50	150	
1 gatehouse superstructure	800	
		87,500

Dam No. 55:		
2 acres clearing and grubbing, at $40	$80	
1 bailing and draining	416	
1,700 cubic yards surface stripping, at 12 cents	204	
10,000 cubic yards excavation of earth, at 20 cents	2,000	
2,600 cubic yards core-wall masonry, at $5	13,000	
1,500 cubic yards puddle, at $1	1,500	
800 cubic yards broken-stone lining, at $1.50	1,200	
700 cubic yards soiling, at 50 cents	350	
19,000 cubic yards embankment, at 25 cents	4,750	
2,400 square yards slope paving, at 70 cents	1,680	
2,100 square yards sodding, at 20 cents	420	
		$25,600
Dam No. 56:		
3 acres clearing and grubbing, at $40	120	
1 bailing and draining	776	
4,200 cubic yards surface stripping, at 12 cents	504	
2,500 cubic yards excavation of earth, at 20 cents	500	
1,400 cubic yards foundation excavation of hardpan, at 75 cents	1,050	
4,400 cubic yards core-wall masonry, at $5	22,000	
2,500 cubic yards puddle, at $1	2,500	
2,000 cubic yards broken-stone lining, at $1.50	3,000	
1,700 cubic yards soiling, at 50 cents	850	
30,000 cubic yards embankment, at 25 cents	7,500	
6,000 square yards slope paving, at 70 cents	4,200	
5,000 square yards sodding, at 20 cents	1,000	
		44,000
Dam No. 57, East Branch Fish Creek:		
5 acres clearing and grubbing, at $40	200	
1 bailing and draining	2,520	
7,500 cubic yards surface stripping, at 12 cents	900	
95,000 cubic yards excavation of earth, at 20 cents	19,000	
3,000 cubic yards foundation excavation of hardpan, at 75 cents	2,250	
17,000 cubic yards core-wall and spillway masonry, at $5	85,000	
5,000 cubic yards protection-wall masonry, at $6	30,000	
580 cubic yards coping on spillway and protection walls, at $15	8,700	
37,000 cubic yards wasteway paving, at $4	148,000	
5,300 cubic yards puddle, at $1	5,300	
3,400 cubic yards broken-stone lining, at $1.50	5,100	
2,900 cubic yards soiling, at 50 cents	1,450	
68,000 cubic yards embankment, at 25 cents	17,000	
10,000 square yards slope paving, at 70 cents	7,000	
8,700 square yards sodding, at 20 cents	1,740	
10,000 feet B. M. oak timber, at $40 per M	400	
10,000 feet B. M. pine timber, at $30 per M	300	
600 linear feet holes for dowels, at 10 cents	60	
500 linear feet 2½-inch steel shafting, at 60 cents	300	
4,000 pounds steel rods, bolts, etc., at 7 cents	280	
28,000 pounds steel I-beams, at 5 cents	1,400	
25 sets mechanism for spillway sluices, at $100	2,500	
1 turbine with gearing and shafting, at $600	600	
		340,000

Dam No. 58:		
5 acres clearing and grubbing, at $40	$200	
1 bailing and draining	2,300	
9,000 cubic yards surface stripping, at 12 cents	1,080	
100,000 cubic yards excavation of earth, at 20 cents	20,000	
18,200 cubic yards core-wall masonry, at $5	91,000	
7,500 cubic yards puddle, at $1	7,500	
4,400 cubic yards broken-stone lining, at $1.50	6,600	
3,800 cubic yards soiling, at 50 cents	1,900	
190,000 cubic yards embankment, at 25 cents	47,500	
13,200 square yards slope paving, at 70 cents	9,240	
11,400 square yards sodding, at 20 cents	2,280	
168,000 feet B. M. hemlock timber, at $20 per M	3,360	
1,000 pounds steel spikes, at 4 cents	40	
		$193,000
Dam No. 59:		
1 acre clearing and grubbing	40	
1 bailing and draining	610	
700 cubic yards surface stripping, at 12 cents	84	
1,800 cubic yards excavation of earth, at 20 cents	360	
1,250 cubic yards core-wall masonry, at $5	6,250	
530 cubic yards puddle, at $1	530	
360 cubic yards broken-stone lining, at $1.50	540	
300 cubic yards soiling, at 50 cents	150	
14,000 cubic yards embankment, at 25 cents	3,500	
1,080 square yards slope paving, at 70 cents	756	
900 square yards sodding, at 20 cents	180	
		13,000
Dam No. 60:		
2 acres clearing and grubbing, at $40	80	
1 bailing and draining	291	
1,700 cubic yards surface stripping, at 12 cents	204	
600 cubic yards excavation of earth, at 20 cents	120	
950 cubic yards core-wall masonry, at $5	4,750	
430 cubic yards puddle, at $1	430	
450 cubic yards broken-stone lining, at $1.50	675	
370 cubic yards soiling, at 50 cents	185	
16,400 cubic yards embankment, at 25 cents	4,100	
1,350 square yards slope paving, at 70 cents	945	
1,100 square yards sodding, at 20 cents	220	
		12,000
Dam No. 61:		
1 acre clearing and grubbing	40	
1 bailing and draining	325	
1,250 cubic yards surface stripping, at 12 cents	150	
700 cubic yards excavation of earth, at 20 cents	140	
1,300 cubic yards core-wall masonry, at $5	6,500	
600 cubic yards puddle, at $1	600	
650 cubic yards broken-stone lining, at $1.50	975	
550 cubic yards soiling, at 50 cents	275	
26,000 cubic yards embankment, at 25 cents	6,500	
1,950 square yards slope paving, at 70 cents	1,365	
1,650 square yards sodding, at 20 cents	330	
		17,200

Dam No. 62:		
1 acre clearing and grubbing	$40	
1 bailing and draining	132	
800 cubic yards surface stripping, at 12 cents	96	
900 cubic yards excavation of earth, at 20 cents	180	
725 cubic yards core-wall masonry, at $5	3,625	
400 cubic yards puddle, at $1	400	
310 cubic yards broken-stone lining, at $1.50	465	
260 cubic yards soiling, at 50 cents	130	
4,500 cubic yards embankment, at 25 cents	1,125	
930 square yards slope paving, at 70 cents	651	
780 square yards sodding, at 20 cents	156	
		$7,000
Dam No. 63:		
1 acre clearing and grubbing	40	
1 bailing and draining	263	
700 cubic yards surface stripping, at 12 cents	84	
600 cubic yards excavation of earth, at 20 cents	120	
725 cubic yards core-wall masonry, at $5	3,625	
350 cubic yards puddle, at $1	350	
340 cubic yards broken-stone lining, at $1.50	510	
280 cubic yards soiling, at 50 cents	140	
10,000 cubic yards embankment, at 25 cents	2,500	
1,000 square yards slope paving, at 70 cents	700	
840 square yards sodding, at 20 cents	168	
		8,500
Dam No. 64, Beaver Creek:		
1 acre clearing and grubbing	40	
1 bailing and draining	1,068	
1,100 cubic yards surface stripping, at 12 cents	132	
15,000 cubic yards excavation of earth, at 20 cents	3,000	
2,500 cubic yards core-wall masonry, at $5	12,500	
4,300 cubic yards puddle, at $1	4,300	
500 cubic yards broken-stone lining, at $1.50	750	
400 cubic yards soiling, at 50 cents	200	
20,000 cubic yards embankment, at 25 cents	5,000	
1,500 square yards slope paving, at 70 cents	1,050	
1,200 square yards sodding, at 20 cents	240	
31,000 feet B. M. hemlock timber, at $20 per M	620	
52,000 feet B. M. oak timber, at $40 per M	2,080	
		30,980
Dam No. 65:		
1 acre clearing and grubbing	40	
1 bailing and draining	1,064	
1,300 cubic yards surface stripping, at 12 cents	156	
16,000 cubic yards excavation of earth, at 20 cents	3,200	
3,500 cubic yards core-wall masonry, at $5	17,500	
1,650 cubic yards puddle, at $1	1,650	
530 cubic yards broken-stone lining, at $1.50	795	
430 cubic yards soiling, at 50 cents	215	
20,000 cubic yards embankment, at 25 cents	5,000	
1,600 square yards slope paving, at 70 cents	1,120	
1,300 square yards sodding, at 20 cents	260	
		31,000

Dam No. 65A:		
5 acres clearing and grubbing, at $40	$200	
1 bailing and draining	2,004	
1,250 cubic yards surface stripping, at 12 cents	150	
90,000 cubic yards excavation of earth, at 20 cents	18,000	
1,200 cubic yards foundation excavation of rock, at $1.50	1,800	
8,000 cubic yards core-wall and spillway masonry, at $5	40,000	
900 cubic yards protection-wall masonry, at $6	5,400	
200 cubic yards coping for spillway and protection wall, at $15	3,000	
5,600 cubic yards wasteway paving, at $4	22,400	
2,400 cubic yards puddle, at $1	2,400	
500 cubic yards broken-stone lining, at $1.50	750	
400 cubic yards soiling, at 50 cents	200	
45,000 cubic yards embankment, at 25 cents	11,250	
1,500 square yards slope paving, at 70 cents	1,050	
1,200 square yards sodding, at 20 cents	240	
300 linear feet holes for dowels, at 10 cents	30	
1,800 pounds steel rods, at 7 cents	126	
		$109,000
Dam No. 66, Canada Creek:		
6 acres clearing and grubbing, at $40	240	
1 bailing and draining	5,885	
124,000 cubic yards excavation of earth, at 20 cents	24,800	
2,200 cubic yards foundation excavation of rock, at $1.50	3,300	
22,000 cubic yards core-wall and spillway masonry, at $5	110,000	
3,600 cubic yards protection-wall masonry, at $6	21,600	
250 cubic yards spillway and protection-wall coping, at $15	3,750	
9,000 cubic yards wasteway paving, at $4	36,000	
8,000 cubic yards puddle, at $1	8,000	
2,100 cubic yards broken-stone lining, at $1.50	3,150	
1,500 cubic yards soiling, at 50 cents	750	
120,000 cubic yards embankment, at 25 cents	30,000	
6,300 square yards slope paving, at 70 cents	4,410	
4,500 square yards sodding, at 20 cents	900	
400 linear feet holes for dowels, at 10 cents	40	
2,500 pounds steel rods, at 7 cents	175	
		253,000
Total cost of Black River feeder		11,008,552
Enlargement of outlet channels from existing reservoirs on Mohawk-Susquehanna Divide		10,000
Amount, including Black and Salmon rivers reservoirs		18,080,752
Engineering and contingencies, about 10 per cent		1,808,075
Total estimated cost of water-supply system		19,888,827

ESTIMATED COST OF ALTERNATIVE TUNNEL LINE.

Plate 93 shows two methods of bringing water from the proposed Black River reservoir to the main ship canal. The first is by the open feeder, beginning at Carthage and constructed via Rutland Hollow, Sandy Creek, Kasoag, and west branch of Fish Creek, etc., to the main ship canal near Fort Bull. An objection to this line is that it delivers the water too near the west end of summit level. As an alternative proposition, general studies have been made of a tunnel line from Lyon Falls through the intervening ridge into the valley of upper Mohawk River at the village of Northwestern. This tunnel would be 20.5 miles in length, and the estimates have been prepared on the basis of a fall of 123 feet between its two ends. A profile of the same, derived from the data of Black River Canal, is shown on pl. 141. The detail of the tunnel line has not been worked up, but so far as surface indications go the first few miles from Lyons Falls would lie in the Laurentian granite rocks of the Adirondack region. The work would then pass into the Trenton limestone. The last few miles of the work—between some point to the south of Boonville and Northwestern—would lie in the rocks of Hudson River and Utica formations, which include, among others, the Oswego sandstone. It is quite possible, therefore, that an examination might show this an economical line to construct. Without going into the detail, it may be stated that the assumed grade would require—for a section lined throughout its whole length—a channel 12 feet wide and 12 feet deep; such a section lined with smooth brick, permitting a flow of, roundly, 1,200 cubic feet per second. Where lining is required it is proposed to use brick masonry in four courses, with an invert at the bottom and with a semicircular arch at the top. With some allowance for filling irregularities in the rock, the brick masonry of such a section may be estimated at 4 cubic yards per running foot, the rock excavation amounting to 12 cubic yards per running foot.

In making the following estimates shafts have been assumed 1 mile apart. Dimensions proposed for the shafts are 10 feet by 19 feet, which give, say, 7 cubic yards per running foot.

We may write a trial estimate per linear foot of tunnel, as follows:

12 cubic yards of rock excavation, at an average price of $3	$36
4 cubic yards of brick masonry with vitrified brick facing, at an average of $12	48
Incidentals	1
Total	$85

On the foregoing basis a complete estimate for 20.5 miles of tunnel with lining would stand as follows:

20.5 miles of tunnel equals 108,240 linear feet, at $85 per linear foot	$9,200,400
4,900 linear feet of shafts, 7 cubic yards per linear foot, at $4 per cubic yard	137,200
1 portal at lower end of tunnel, including channel protection below same	30,000
Gatehouse and regulating works at upper end of tunnel	150,000
Dredging channel of Black River	400,000
35,000 cubic yards of refilling shafts, at 20 cents	7,000
Special strengthening masonry under shafts in order to stand refilling	75,400
Amount	$10,000,000

The foregoing estimate may be taken as a maximum, the prices used being large enough, it is believed, to cover quite adverse conditions, such as rock difficult to work and considerable quantities of water to be cared for. Lining is provided throughout the whole length, although it is probable that lining will not be required for more than one-half the entire length.

The following estimate may be taken to represent the possible minimum cost of this tunnel.

In this second estimate it is assumed that one-half of the tunnel will not need lining. The section for this portion is taken equal to 243 square feet, or 9 cubic yards per linear foot. The minimum estimated cost per linear foot with lining is as follows:

12 cubic yards of rock excavation, at $3	$36
4 cubic yards of brick masonry, at $10	40
Incidentals	1
Total	$77

MINIMUM COMPLETE ESTIMATE.

54,120 linear feet of tunnel with lining, at $77	$4,167,240
54,120 linear feet of tunnel without lining 9 cubic yards of rock excavation, at $3, $27 per linear foot	1,461,240
4,900 linear feet of shaft, 7 cubic yards per linear foot, at $3 per cubic yard	102,900
Portal at lower end and channel protection	25,000
Gatehouse and regulating works at upper end	125,000
Dredging channel of Black River	400,000
Refilling shafts	7,000
Special strengthening of masonry under shafts	69,860
Amount	$6,358,240

The actual cost of this tunnel, if ever constructed, may be expected to fall somewhere between the two values of $10,000,000 and $6,358,240. For purposes of comparison we will take it at $8,000,000.

With the tunnel line adopted, if we assume Salmon River reservoir as still required, we may consider the following: In order to save constructing a channel from Salmon River to Kasoag, it would be preferable to cut the necessary outlet channel from Dam No. 76 into head waters of Mad River, which is tributary to west branch of Fish Creek at Camden. This plan would sacrifice about 1,000,000,000 cubic feet of Salmon River storage, it being impossible to draw from the vicinity of Dam No. 76 below about the 918 level. The approximate cost of discharge channel and regulating works at Dam No. 76 would be $150,000. There would also be required a channel of the nominal capacity of from 300 to 400 cubic feet per second from Dam No. 54, above Taberg, to main ship canal near Fort Bull.

We may now write a complete estimate of the cost of water supply by the alternative tunnel line, including Salmon and Black rivers reservoirs, a feeder channel from Dam No. 54 to Fort Bull, together with the enlargement of the outlet channel from present State reservoirs on Mohawk-Susquehanna divide.

The following is the complete estimate:

Tunnel complete, as per preceding estimate		$8,000,000
Black River reservoir, as estimated		5,712,000
Salmon River reservoir, as estimated		1,350,000
Discharge channel and regulating works at Dam No. 76		150,000
Land and water power damages in upper Mohawk valley		30,000
Dam No. 54	$87,500	
Dam No. 55	25,600	
Dam No. 56	44,400	
Dam No. 57	340,000	
Dam No. 58	193,000	
Dam No. 59	13,000	
Dam No. 60	12,000	
Dam No. 61	17,200	
Dam No. 62	7,000	
Dam No. 63	8,500	
Dam No. 64	31,000	
Dam No. 65	31,000	
Dam No. 65A	109,000	
Dam No. 66	253,000	
2,000 acres of land, at $15	30,000	
70 acres clearing and grubbing, at $40	2,800	
380 acres clearing and burning, at $15	5,700	
3,470,000 cubic yards earth excavation, at 20 cents	694,000	
100,000 cubic yards puddle, at $1	100,000	
100,000 cubic yards of riprap, at $1.10	110,000	
85,000 linear feet of fencing, at 10 cents	8,500	
25 miles telephone line, at $330	8,250	
Changes of highway	9,000	
Highway bridges	62,500	
Railway bridges	20,000	
Special bank protection	15,000	
1 dredge	27,000	
		2,264,950
Enlarging outlet channel from reservoirs on Mohawk-Susquehanna divide		10,000
Total		$17,516,950
Add for contingencies and engineering, about 10 per cent		1,751,050
Amount		$19,268,000

A comparison of the estimated cost of the proposed open-channel feeder with the alternative tunnel is as follows:

Estimated cost of open channel, with reservoirs, etc	$19,800,000
Estimated cost of tunnel, with reservoirs, etc	19,268,000
Difference	$532,000

It is the opinion of the author, taking into account the large saving of water which would result from the tunnel line, that, even though the cost on that route were to run as high as the maximum estimate of $10,000,000, it would, on the whole, be the preferable construction to make. The absolute safety of the tunnel may be taken into account in reaching this conclusion.

Tables Nos. 135 and 136 give the detail of water supply by alternative tunnel line. Inasmuch as these two tables are arranged like several of the previous ones, they are considered self-explanatory.

Referring to "Estimate of Summit Level Water Supply," it appears that 1,600 cubic feet per second, including feeder losses, was fixed upon for supply of summit level of 30-foot canal and 1,400 cubic feet per second for supply of 21-foot canal. The foregoing estimates of cost are for summit-level supply of 30-foot canal.

For a 21-foot canal the approximate cost of summit-level water supply, computed as in the foregoing, is placed at $18,000,000. This figure has been arrived at by rapid approximation from general data. It is possible that more detailed study might change it somewhat. The limitation of time to August 1, 1899, has not permitted of giving this particular problem other than casual attention.

Moreover, the foregoing statements of cost have all been made on the supposition that whichever line be adopted Salmon and Black rivers reservoirs will both be required. Let us now examine as to whether Salmon River reservoir could not be dispensed with in case of adopting the alternative tunnel line.

According to Table No. 131, there would remain in Black River reservoir at the end of the water year 1895 something like 5.26 inches on the catchment area, equivalent to 22,175,000,000 cubic feet. This is on the basis of 1,600 cubic feet per second, supply by open feeder. Again, Table No. 133A shows in column (9) 3.75 inches in store in Salmon River reservoir at end of the water year 1895; 3.75 inches on Salmon River catchment area is, as per Table No. 132, 1,655,000,000 cubic feet.

On the basis of 1,200 cubic feet per second supply by alternative tunnel line the conditions are as follows: Table No. 135 gives quantity of water to be furnished by the several sources of supply, as there shown in detail, and Table No. 133, which exhibits state of Salmon River reservoir, shows 5.19 inches on the catchment area in store at end of the water year 1895. This latter figure is equivalent to 2,300,000,000 cubic feet. Also Black River reservoir would hold in store at end of the water year 1895, say, 7.12 inches on Black River catchment area, equivalent to 29,700,000,000 cubic feet.

The gain in Black River reservoir storage in the year of lowest recorded run off by adoption of tunnel line is therefore (29,700,000,000—22,175,000,000)=7,525,000,000 cubic feet. At Salmon River reservoir the saving is (2,300,000,000—1,655,000,000)=645,000,000 cubic feet.

These figures show at once that the gain in storage in Black River reservoir, under the assumed conditions, is so large as to render Salmon River reservoir probably unnecessary. At any rate, it would only be required in the rare extreme dry year which may occur two or three times in a century. If we assume that it may be omitted from immediate consideration, the estimate is reduced not only by the cost of the reservoir itself, but by decreased cost of feeder from Fish Creek, which may then be made with reference to the nominal minimum flow of that creek of, say, 100 cubic feet per second. On this basis a complete estimate for summit-level water supply by tunnel line, etc., would stand as follows:

Tunnel complete, as per estimate	$8,000,000
Black River reservoir, as per estimate	5,712,000
Land and water power damages in upper Mohawk Valley	30,000
Feeder complete, including dams, Taberg to Fort Bull	1,750,000
Enlarging outlet channels on Mohawk-Susquehanna divide	10,000
Total	15,502,000
Add for contingencies and engineering, about 10 per cent	1,548,000
Amount	17,050,000

In regard to this latter estimate it may be remarked that possibly further study of the matter might indicate a way to reduce the final amount to perhaps $16,000,000. At present, however, in view of the eight-hour day and the clear tendency to increase pay of common labor, it does not seem best to make the final amount less than about $17,000,000, as in the foregoing. In any case, with Salmon River reservoir omitted, the figure of $16,000,000 may be taken as fairly applying to the summit-level supply for a 21-foot canal.

SOURCE OF MATERIALS AND COST OF SAME.

The region wherein it is proposed to construct the works here reported upon will furnish all the material, such as sand and building stone, generally without long hauls. For a considerable portion of the proposed feeder line quarries may be opened in the immediate vicinity at small cost.

In the vicinity of Carthage and along the feeder line between that place and East Watertown there are a number of quarries already opened in the Trenton limestone which will furnish stone of proper quality for the works to be built at low cost. To the north and east of Carthage the granitic rocks of the Adirondack region appear, and without doubt stone for face masonry of Dams Nos. 1 and 2 at Carthage may be obtained from their horizon. At site of Dam No. 8, near Adams, limestone of proper quality for backing and core wall can be quarried immediately at the site of the dam.

To the south of Sandy Creek we enter a shale region without building stone, except on the surface. In many places the surface of the ground is thickly studded with granite bowlders This is particularly marked just north of the village of Pierpont Manor, where there is a belt of granite bowlders crossing the feeder line, and which is about one-half mile in width, the stone being so plentiful in many places as to almost cover the surface of the ground. The general direction of this belt and the character of the stone in a region where the natural rock is shale leads to the view that this is a medial moraine, which, descending from the higher country to the northeast, brought with it the characteristic rocks of the Adirondack hills, depositing them here as it moved forward in a southwestern course.[1]

There are a number of places along the feeder line where strips of beach gravel, which mark the former lake border, may be seen. The Luther gravel beds, immediately on the feeder line at East Watertown, are of this character, but luckily they are not very deep, being underlaid by Trenton limestone, in which rock the channel of the feeder, if constructed, would lie entirely at this point.

At Chaumont, a few miles west of Watertown, there are fine limestone quarries. At one of these which was visited there are from two to three acres of a 32-inch course uncovered, which lies nearly as level as a floor. Small stone are sold from these quarries to the Solvay Process Company, at Syracuse, for $1 per ton, delivered, freight amounting to 55 cents per ton. These stone have a specific gravity of 2.7 and weigh 168 pounds per cubic foot, the absorption in twenty-four hours amounting to 1 in 3,000.

The loss in freezing and thawing five successive times was 1 in 7,530. The crushing strength per square inch is 23,641 pounds. The tests at quarry show weight of broken stone, when broken to pass through 2-inch ring, at 2,457 pounds per cubic yard, and when broken to pass through 1-inch ring, 2,484 pounds per cubic yard. The foregoing statistics as to stone at Chaumont are based on statements made by parties at the quarries.

Immediately under the 32-inch course there is a 16-inch course. The other courses range from 4 to 10 inches.

The following prices were furnished for stone at quarry:

Broken stone to pass 3-inch ring	**per ton**	**$0.40**
Face stone, uncut	**per cubic yard**	**1.50**
Backing of thick courses	**do**	**1.00**
Backing of thin courses	**do**	**.75**
Face stone cut to ½-inch joints, 10 inches back	**do**	**6.00**
Dimension stone, ¼-inch joint, 8-cut work	**do**	**10.00**

Frieght to points on the Rome, Watertown and Ogdensburg Railway may be expected to average about $1 per cubic yard.

The large dam on Salmon River (No. 73) will be located on the Oswego sandstone, and material for backing, core walls, etc., may be obtained from quarries in the immediate vicinity. The face stone will be brought from abroad. Material for core walls of dams Nos. 74, 75, and 76 can be obtained from quarries about 2 to 2½ miles distant. Building sand of proper quality occurs in the vicinity.

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[1] For an extended discussion of physical features of Jefferson County, and covering many points of interest in the surface geology of the proposed feeder line, see a chapter on "Evidence of glacial action and physical features of Jefferson County," contributed by Frank A. Hinds, C. E., to a History of Jefferson County, edited by Edgar C. Emerson, and published in 1898.

At White Lake, a station on the Adirondack and St. Lawrence division of the New York Central and Hudson River Railroad, there is a fine granite quarry, from which coping and dimension stone may be conveniently obtained. The granite occurs here in a ledge 50 feet in height, from which it is quarried without stripping.

Portland cements are manufactured in New York State at Wayland, Syracuse, and Glens Falls, present prices ruling from $1.50 to $1.75 per barrel at the works. Taking into account, therefore, all the conditions, there is no reason for doubting that the proposed works can be cheaply and efficiently constructed.

As regards quality of masonry for dams, the general character of the work estimated upon may be determined by reference to a description of the Indian River dam appearing in Engineering News of May 18, 1899. This dam was substantially built of granite rubble work in 1898; the cement, ironwork, contractors' supplies, etc., being transported by wagon over a mountain road for 20 miles, in the course of which there was a summit 1,200 feet high. Face stone, backing, slope paving, riprap, broken stone for concrete and lining were all obtained immediately at the dam site. The average cost per cubic yard of masonry, laid during the months of July and August, 1898, when the work was well under way and the conditions favorable, was as follows:

Quarrying face stone, average for month's work	$0.35
Labor of laying masonry	.53
Labor of pointing	.15
Mixing mortar and concrete and crushing stone	.20
Cost of cement	2.00
Cost of sand	.15
General expenses, superintendence, etc	.27
Total	3.65

Generally, for the dams included in the present work, the material will not be as convenient to the site as at Indian Lake, but taking into account that Portland cement on the work at Indian Lake cost about $3.40 per barrel, it is believed that a considerable portion of the masonry for the proposed reservoirs and dams of the present project can be constructed for about the figure determined by experience at Indian Lake.

PRICES USED IN ESTIMATES.

The following are the prices used in estimates:

Bailing and draining (a gross price determined as a matter of judgment to fit each particular case).

This item has been used throughout the estimates as a partial contingency item for balancing up the estimate for each structure to even dollars, or even hundreds of dollars, as the case may be.

Clearing and grubbing on railway, per acre	$30
Clearing and grubbing on feeder line, per acre	40

A distinction has been made between price of clearing and grubbing on changes of railway and clearing and grubbing on feeder line because on the feeder line the grubbed stumps should be hauled well outside the limits of the work and left under the spoil banks.

Trenton limestone and sandstone, rock excavation in feeder cuts ... per cubic yard	$0.65
Trenton limestone, sandstone, and granite rock excavation in railway cuts ... do	.80
Shale rock excavation in feeder cuts ... do	.55
Rock channeling in Trenton limestone ... per square foot	.10
Glacial drift hardpan ... per cubic yard	.35
Surface stripping under embankments, etc ... do	.12
Ordinary earth excavation, including topsoil, earth, muck, sand, gravel, clay, bowlders, and fragmentary rock displaced from its original bed, not exceeding 1 cubic yard content, and of other material overlying hardpan or bed rock, per cubic yard	.20
Excavation of earth in railway cuts	.25
Rock excavation in tunnel ... per cubic yard	3.00
Rock excavation in tunnel shafts ... do	4.00
Foundation excavation of limestone, sandstone, or granite, per cubic yard	1.50
Foundation excavation of shale rock ... per cubic yard	1.00
Foundation excavation of hardpan in core-wall trenches, etc., per cubic yard	.75
Refilling of shafts ... per cubic yard	.20
Brick masonry in tunnel lining ... do	12.00 to 16.00
Brick masonry backing in tunnel ... do	10.00
Rubble masonry in core walls, interior of dams, etc ... do	4.00 to 5.00
Concrete ... do	5.00
Granite spillway coping on large dams ... do	25.00
Granite spillway facing and coping on small dams ... do	15.00
Coursed rubble face masonry in dams ... do	7.00
Paving on slopes of earth embankments, etc ... per square yard	.70
Rough riprap ... per cubic yard	1.00 to 1.10
Broken stone lining ... do	1.00 to 1.50
Protection-wall masonry ... do	5.00
Coping for dams and protection-wall masonry ... do	15.00
Spillway masonry ... do	5.00 to 6.00
Gatehouse masonry ... do	6.00
Discharge-culvert masonry ... do	6.00
Waste-way paving ... do	4.00

This item includes a paving of large bowlders with the interspaces filled with concrete.

Pine timber in work ... per M	$30.00
Hemlock timber in work ... do	20.00
Oak timber in work ... do	40.00 to 50.00
Piling ... per linear foot	.20
Fencing, of stone wall ... do	.25

Fencing, of post, wire and top rail	per linear foot	$0.10
Soiling on back slope of embankments	per cubic yard	.50
Embankments of earth, including dams, dikes, etc	do	.25
Roadway embankments across reservoirs	do	.12

This item includes the making of embankments for new roadways across Black and Salmon rivers reservoirs, where the material will be taken up with scrapers at the sides, the embankments to be protected by riprap.

Sodding on back slope of embankments	per square yard	$0.20

Generally the sod will be cut from meadows within the area taken for the reservoirs, feeder line, etc.

Puddle in place in work, including the furnishing of clay, sand, and gravel	per cubic yard	$1.00
Clearing and burning timber on reservoir sites on right of way	per acre	15.00
Steel rods and bolts in work	per pound	.07
Drilling holes for dowels	per linear foot	.10
Gas-pipe railing	do	1.00
Operating mechanism for spillway sluices	per set	100.00
Small turbine water wheel, with shafting and gearing		600.00
Two-and-one-fourth-inch steel shaft and gate rods, per linear foot		.60
Gas iron pipe laid	per pound	.02
Steel I-beams	do	.05
Riveted steel pipe	do	.07
Gatehouse superstructures		800.00 to 1,000.00
Railway ballast	per cubic yard	.40
Railway ties	each	.50
Steel rails	per ton	35.00
Angle bars	per pound	.0225
Bolts and spikes	do	.025
Track laying	per mile	400.00
Telephone line	do	330.00
Telegraph line	do	300.00

The following prices of stop valves and sluice gates are based on net quotations furnished by the Eddy Valve Company, such additions being made to the net price as are necessary to cover cost of freight and setting:

Six-inch double-disk valve gate	$10.00
Twelve-inch double-disk valve gate	30.00
Thirty-six-inch double-disk valve gate	350.00
Sixty-inch double-disk valve gate	1,200.00
Seventy-two-inch double-disk valve gate	1,500.00
Thirty-six-inch sluice gates	250.00
Sixty-inch sluice gates	400.00
Seventy-two-inch sluice gates	700.00

Gate stands are estimated from $10 to $25 each, according to size and finish, and gearings at $10.

ESTIMATED COST OF LABOR.

The estimates have further been prepared on the basis of eight hours work per day for the different classes of labor, as follows:

Foremen	$3.00 to	$4.00
Hoisting engineers	2.00 to	2.25
Firemen		1.75
Coal heavers		1.25
Machinists	2.25 to	2.50
Pipe fitters		1.75
Blacksmiths	2.00 to	2.50
Blacksmiths' helpers		1.50
Carpenters	2.00 to	2.50
Bricklayers	3.00 to	4.50
Stone masons	3.00 to	3.50
Masons' helpers		1.50
Stonecutters	2.00 to	3.00
Quarrymen		1.50
Drillmen		2.00
Drillmen's helpers		1.50
Hammermen		1.50
Riggers, tagmen, brakemen, etc		1.50
Teams with driver	3.00 to	3.50
Drivers		1.25
Watchmen		1.50
Timekeepers		1.75
Bookkeepers	2.50 to	3.50
Intelligent labor		1.50
Common labor, white	1.20 to	1.30
Common labor, colored	1.00 to	1.30
Common labor, Italian	.90 to	1.10
Powder men	1.50 to	1.75
Bell and hoist topmen		1.75
Heading foremen		2.50
Water boys		.75

It is believed that under existing conditions in the State of New York labor can be obtained for the foregoing prices, and probably in many cases for somewhat less.

ACKNOWLEDGMENTS.

The following persons have been employed at different times on the engineering work under the author's charge, including and above the rank of stadiaman:

Name.	Rank.	Date of employment.
J. Y. McClintock	Principal assistant engineer	Aug. 8, 1898
Wm. B. Landreth	do	Oct. 19, 1898
Wallace Greenalch	do	Nov. 16, 1898
H. F. Northrup	do	Sept. 26, 1898
Willard D. Lockwood	do	Sept. 1, 1898
A. M. Evans	Draftsman	Oct. 21, 1898
Henry D. Alexander	do	Aug. 19, 1898
J. T. Parsons	do	Oct. 10, 1898
Frank W. Bristow	do	Nov. 21, 1898
Chas. E. Gordon	Instrumentman	Aug. 20, 1898
F. H. Crafts	do	Aug. 22, 1898
W. A. Miller	do	Oct. 13, 1898
G. C. Mills	do	Sept. 1, 1898
Wm. Crennel, jr	do	Aug. 22, 1898
C. H. Semper	do	Oct. 27, 1898
Carl L. Bannister	do	Sept. 2, 1898
Robert E. Horton	Computer	Aug. 29, 1898
Ralston Williams	Clerk	Aug. 11, 1898
A. F. Alexander	Stenographer	Nov. 1, 1898
George E. Cook	Computer	Sept. 2, 1898
Wm. L. McDonough	Superintendent of borings	Nov. 15, 1898
H. Fay Allen	Recorder	Oct. 21, 1898
B. E. Failing	do	Do.
J. Dana Luther	do	Aug. 22, 1898
Charles F. Brenn	Rodman	Oct. 21, 1898
Harry C. Brown	do	Oct. 20, 1898
Charles A. Hunt	do	Aug. 22, 1898
F. McCarthy	Stadiaman	Do.
Gail B. Porter	do	Aug. 24, 1898
J. E. Thomas	do	Aug. 21, 1898
E. V. Allendorph	do	Aug. 22, 1898
H. T. Rice	do	Aug. 25, 1898
Charles Kiehm	do	Aug. 27, 1898
Joseph W. Howe	do	Sept. 2, 1898
G. A. Smith	do	Sept. 26, 1898
Robert L. Burns	do	Nov. 1, 1898
H. E. Tiffany	do	Oct. 21, 1898
Arthur L. Saunders	do	Do.
Louis Meyer	do	Oct. 17, 1898
A. W. Gillis	do	Nov. 21, 1898

Where there are so many it is perhaps invidious to specially mention any. The author, therefore, merely makes the general acknowledgment that his assistants have, generally speaking, all performed the parts assigned to them satisfactorily. So far as possible to do so, every man employed was selected with reference to special fitness for the work he was called upon to perform. The author wishes to thank the Board for perfect freedom in selection of assistants, inasmuch as under this system previous personal acquaintance with nearly all the men employed enabled the author to reach a maximum efficiency in the conduct of the work in the minimum time.

The author has construed his function to be mostly that of a collector of facts, and has, therefore, so far as possible, avoided expressing opinions, except as necessary for proper interpretation.

Hoping the facts and statements herein presented may be of use to your Board in reaching final conclusions,

I am, gentlemen, very respectfully,

GEO. W. RAFTER.

The BOARD OF ENGINEERS ON DEEP WATERWAYS.

APPENDIX NO. 17.

LAKE CHANNELS, LAKE ERIE TO LAKES HURON, MICHIGAN, AND SUPERIOR.

DETROIT, MICH., *April 12, 1900.*

GENTLEMEN: I have the honor to submit a report of an estimate for a 21 and a 30 foot channel from deep water in Lake Erie to deep water in Lake Huron, through the Detroit River, Lake St. Clair, and St. Clair River; and from deep water in St. Marys River, off Lime Island, to deep water in Lake Superior, for a standard low-water surface, and a standard low-water surface with Lake Erie regulated.

The estimates are based on the results of soundings taken in 1859, 1867 to 1871, 1873 to 1879, and 1895 by the United States Lake Survey, and additional soundings, borings, character of river beds, etc., that had been taken at different times in the regular channel improvements by the United States engineers. Original tracings were obtained from Lieut. Col. G. J. Lydecker, Corps of Engineers, U. S. Army, and blue-print copies made. The proposed channel lines were laid out on the prints, and on charts where originals were not obtainable.

All elevations in this report are given in feet and decimals above mean tide at New York, and depend upon the adopted elevation of the bench mark, to which they are referred.

AUTHORITIES.

Lake Erie at mouth of the Detroit River.—Soundings taken from 1874–1879 by the United States Lake Survey as shown on Coast Chart No. 7, of Lake Erie.

Detroit River.—Detail soundings and borings taken in 1897–98 and 1899 by the United States engineers, also soundings taken in 1873 by the United States Lake Survey as shown on original tracings.

Lake St. Clair.—Soundings taken from 1867 to 1871 by the United States Lake Survey as shown on chart of Lake St. Clair and additional soundings off Grosse Pointe by the United States engineers.

St. Clair River.—Soundings taken in 1867 by the United States Lake Survey as shown on original tracings and additional information by the United States engineers.

Lake Huron at head of St. Clair River.—Soundings taken in 1859 by the United States Lake Survey, as shown on original tracings, chart of south end of Lake Huron, and additional information by the United States engineers.

St. Marys River.—Soundings taken in 1895 by the United States Lake Survey as shown on original tracings, and additional soundings and borings by the United States engineers.

WATER SURFACE ELEVATIONS.

Lake Erie to Lake Huron.—The elevations for a standard low-water surface, and a water surface with Lake Erie regulated, having been determined for Lake Erie, Lake St. Clair, and Lake Huron, the fall at different points in the rivers was reduced from gauge readings taken June 26 to July 1, 1899. The elevations of gauges were determined by a line of precise levels from U. S. B. M. Gibraltar, 1877, elevation 582.45 above mean tide at New York. The elevations at different points are given in the following table:

Station.[a]	Gauge.	Water-surface elevations.		
		June 26 to July 1, 1899.	Standard low water.	With Lake Erie regulated.
287+00	No. 1. Fort Gratiot Light-house (Lake Huron)	580.41	579.00	580.00
313+00	G. T. R	580.10	578.69	579.71
382+00	Kendall	579.55	578.15	579.21
519+00	Dry dock	579.17	577.79	578.92
695+00	No. 5. Marysville	578.68	577.32	578.54
990+00	No. 6. St. Clair	577.90	576.58	577.95
1402+00	No. 7. Marine City	576.98	575.72	577.30
1781+00	No. 8. Algonac	576.27	575.06	576.83
2352+00	No. 9. upper end of United States canal	575.65	574.52	576.58
2424+15	Lower end of United States canal	575.50	574.38	576.48
3312+15	No. 11. Windmill Point Light-house	575.12	574.00	576.10
3732+15	No. 12. Detroit, 18th street	574.53	573.49	575.90
4210+00	No 14. Wyandotte	573.97	573.02	575.78
4590+65	No. 15. Gibraltar	572.65	571.77	574.82
	Lake Erie		571.30	574.50

[a] Stationing is the same as shown on maps.

St. Marys River.—The elevations for a standard low-water surface and a water surface with Lake Erie regulated having been determined for the lower end of river, at the locks, and at Lake Superior, the fall at different points was deduced from elevations established by the United States engineers from U. S. B. M. No. 1, at Marquette, elevation 609.93 above mean tide at New York. The elevations are given in the following table:

Station.	Gauge.	Water-surface elevations.	
		Standard low water.	With Lake Erie regulated.
Zero	Head of St. Marys River (Lake Superior)	600.69	600.69
255+00	Point Aux Pins Light-house	600.45	600.45
603+97	Head of lock	600.11	600.11
611+37	Foot of lock	581.27	582.27
680+00	Sault Ste. Marie	581.02	582.02
740+00	Mission Point	580.52	581.52
886+00	Frechette Point	580.12	581.12
990+00	Six-Mile Point	579.92	580.92
1566+00	West Neebish Rapids, upper end	579.87	580.87
1604+00	West Neebish Rapids, lower end	579.00	580.00

Width and depth of channels.

	21-foot channel.	30-foot channel.
	Feet.	*Feet.*
Lake Erie to Lake Huron:		
From deep water in Lake Erie to Bar Point, Detroit River	23 by 800	32 by 1,000
From Bar Point, Detroit River, to head of St. Clair River	21 by 600	30 by 600
From head of St. Clair River to deep water in Lake Huron	23 by 800	32 by 1,000
St. Marys River:		
Below the locks	21 by 600	30 by 600
Above the locks	21 by 600	30 by 600
Approaches to the locks	(a)	(a)

[a] Shown on maps.

The side slopes as estimated are vertical in rock, and in all other material 1 on 2. Alignment of channels is given, page 89.

LOCKS AT SAULT STE. MARIE.

The Poe lock on the American side and the Canadian lock are both available for a standard low-water 21-foot channel. An estimate has been made of the cost of construction of a lock for the 30-foot channel to be built on the site of the present Weitzel lock. The dimensions of this lock are 80 by 740 feet, with a lift of 18.8 feet for a standard low-water channel, and 17.8 feet for a standard low-water channel with Lake Erie regulated.

Estimates for a 21-foot channel, standard low water.

LAKE ERIE TO LAKE HURON.

Lake Erie at mouth of the Detroit River:	
Sand and clay, 596,333 cubic yards, at $0.09	$53,670
Detroit River:	
Sand and clay, 923,179 cubic yards, at $0.09	83,086
Sand, clay, bowlders, and gravel, 359,723 cubic yards, at $0.40	143,889
Rock (limestone), 474.304 cubic yards, at $2.50	1,185,760
Lake St. Clair:	
Sand, clay, and gravel, 5,513,821 cubic yards, at $0.15	827,073
St. Clair River:	
Sand, clay, and gravel, 614,234 cubic yards, at $0.09	55,281
Foot of Lake Huron:	
Sand, clay, and gravel, 1,198.293 cubic yards, at $0.30	359,488
Total for waterway from Lake Erie to Lake Huron	2,708,247

LAKE HURON TO LAKE SUPERIOR.

St. Marys River via West Neebish, below the lock:	
Sand, clay, gravel, mud, and soft clay, 13,539,481 cubic yards, at $0.08	$1,083,158
Sand, clay, gravel, and bowlders, 4,535,454 cubic yards, at $0.40	1,814,182
Rock (limestone), dry, 2,444,444 cubic yards, at $1.10	2,688,888
Total for waterway from Lake Huron to Lake Superior	5,586,228
Waterway from Lake Erie to Lake Huron	2,708,247
Total for waterway from Lake Erie to Lake Superior	8,294,475
Waterway from Lake Erie to Lake Michigan, same as from Lake Erie to Lake Huron	2,708,247

Standard low water with Lake Erie regulated.

LAKE ERIE TO LAKE HURON.

Detroit River:	
Sand, clay, bowlders, and gravel, 158,997 cubic yards, at $0.40	$63.599
Rock (limestone), 266,482 cubic yards, at $2.50	666,205
Lake St. Clair:	
Sand, clay, and gravel, 2,113,445 cubic yards, at $0.15	317,017
St. Clair River:	
Sand, clay, and gravel, 414,924 cubic yards, at $0.09	37,343
Foot of Lake Huron:	
Sand, clay, and gravel, 829,874 cubic yards, at $0.30	248,962
Total for waterway from Lake Erie to Lake Huron	1,333,126

LAKE HURON TO LAKE SUPERIOR.

St. Marys River via West Neebish, below the lock:	
Sand, clay, gravel, mud, and soft clay, 12,378,555 cubic yards, at $0.08	$990,284
Sand, clay, gravel, and bowlders, 3,811,009 cubic yards, at $0.40	1,524,404
Rock (limestone), dry, 2,255,555 cubic yards, at $1.10	2,481,111
Total for waterway from Lake Huron to Lake Superior	4,995,799
Waterway from Lake Erie to Lake Huron	1,333,126
Total for waterway from Lake Erie to Lake Superior	6,328,925
Waterway from Lake Erie to Lake Michigan, same as from Lake Erie to Lake Huron	1,333,126

Estimates for a 30-foot channel, standard low water.

LAKE ERIE TO HURON.

Lake Erie at mouth of the Detroit River:	
Sand and clay, 7,242,244 cubic yards, at $0.09	$651,802
Detroit River:	
Sand and clay, 7,181,367 cubic yards, at $0.09	646,323
Sand, clay, bowlders, and gravel, 2,416,714 cubic yards, at $0.40	966,686
Rock (limestone), 4,869,304 cubic yards, at $2.50	12,173,260
Lake St. Clair:	
Sand, clay, and gravel, 23,844,527 cubic yards, at $0.15	3,576,679
St. Clair River:	
Sand, clay, and gravel, 7,577,139 cubic yards, at $0.09	681,943
Foot of Lake Huron:	
Sand, clay, and gravel, 8,247,118 cubic yards, at $0.30	2,474,135
Total for waterway from Lake Erie to Lake Huron	21,170,828

LAKE HURON TO LAKE SUPERIOR.

St. Marys River via West Neebish, below the lock:	
Sand, clay, gravel, mud, and soft clay, 28,972,701 cubic yards, at $0.08	$2,317,816
Sand, clay, gravel, and bowlders, 11,747,788 cubic yards, at $0.40	4,699,115
Rock (limestone), dry, 4,427,778 cubic yards, at $1.10	4,870,556

Above the lock:	
Sand, clay, and bowlders, 1,063,204 cubic yards, at $0.40	$425,282
Rock (sandstone), 477,778 cubic yards, at $2	955,556
Total for St. Marys River	13,268,325

LOCK AND APPROACHES AT SAULT STE. MARIE, MICH.

Lock:	
Excavation in the dry—	
Clay and small sandstone filling, 88,782 cubic yards, at $0.50	$44,391
Rock (sandstone), 183,050 cubic yards, at $1.50	274,575
Construction of lock	945,905
Operating machinery	100,000
Total	1,364,871
Approaches:	
Excavation under water—	
Clay and small sandstone filling, 174,645 cubic yards, at $0.15	26,197
Rock (sandstone), 301,197 cubic yards, at $2	602,394
Excavation in the dry—	
Clay and small sandstone filling, 379,199 cubic yards, at $0.50	189,600
Rock (sandstone), 474,205 cubic yards, at $1.50	711,308
Total	1,529,499
Timber cribs—	
Pine, 4,323 M, at $30	129,690
Hemlock, 7,738 M, at $23	177,974
Oak, 209 M, at $50	10,450
Iron drift bolts, 810,390 pounds, at $0.03	24,312
Stone filling, 125,940 cubic yards, at $0.60	75,564
Total	417,990
Right of way for approaches	25,000

SUMMARY.

Lake Erie to Lake Superior:	
Lock	$1,364,871
Approaches—	
Excavation	1,529,499
Timber cribs	417,990
Right of way	25,000
St. Marys River	13,268,325
Waterway from Lake Huron to Lake Superior	16,605,685
Waterway from Lake Erie to Lake Huron	21,170,828
Total for waterway from Lake Erie to Lake Superior	37,776,513
Lake Erie to Lake Michigan, same as waterway from Lake Erie to Lake Huron	21,170,828

Standard low water with Lake Erie regulated.

LAKE ERIE TO LAKE HURON.

Lake Erie at mouth of the Detroit River:	
Sand and clay, 3,976,978 cubic yards, at $0.09	$357,928
Detroit River:	
Sand and clay, 4,966,597 cubic yards, at $0.09	446,994
Sand, clay, bowlders, and gravel, 1,807,659, cubic yards, at $0.40	723,064
Rock (limestone), 3,043,749 cubic yards, at $2.50	7,609,373

Lake St. Clair:	
Sand, clay, and gravel, 19,618,975 cubic yards, at $0.15	$2,942,846
St. Clair River:	
Sand, clay, and gravel, 5,492,053 cubic yards, at $0.09	494,285
Foot of Lake Huron:	
Sand, clay, and gravel, 7,256,391 cubic yards, at $0.30	2,176,917
Total for waterway from Lake Erie to Lake Huron	14,751,407

LAKE HURON TO LAKE SUPERIOR.

St. Marys River, via West Neebish, below the lock:	
Sand, clay, gravel, mud, and soft clay, 26,621,905 cubic yards, at $0.08	2,129,752
Sand, clay, gravel, and bowlders, 10,867,988 cubic yards, at $0.40	4,347,195
Rock (limestone), dry, 4,161,111 cubic yards, at $1.10	4,577,222
Above the lock	
Sand, clay, and bowlders, 1,063,204 cubic yards, at $0.40	425,282
Rock (sandstone), 477,778, at $2	955,556
Total for St. Marys River	12,435,007

LOCK AND APPROACHES AT SAULT STE. MARIE, MICH.

Lock:	
Excavation in the dry—	
Clay and small sandstone filling, 88,782 cubic yards, at $0.50	44,391
Rock (sandstone), 183,050 cubic yards, at $1.50	274,575
Construction of lock	923,493
Operating machinery	100,000
Total	1,342,459
Approaches:	
Excavation under water—	
Clay and small sandstone filling 174,645 cubic yards, at $0.15	26,197
Rock (sandstone), 295.911 cubic yards, at $2	591,822
Excavation in the dry—	
Clay and small sandstone filling 379,199 cubic yards, at $0.50	189,600
Rock (sandstone), 474.205 cubic yards, at $1.50	711,308
Total	1,518,927
Timber cribs—	
Pine, 4,323 M., at $30	129,690
Hemlock, 7,738 M., at $23	177,974
Oak, 209 M., at $50	10,450
Iron, drift bolts, 810.390 pounds, at $0.03	24,312
Stone filling, 125,940 cubic yards, at $0.60	75,564
Total	417,990
Right of way for approaches	25,000

SUMMARY.

Lake Erie to Lake Superior:	
Lock	1,342,459
Approaches—	
Excavation	1,518,927

Lake Erie to Lake Superior—Continued.	
Approaches—Continued.	
Timber cribs	$417,990
Right of way	25,000
St. Marys River	12,435,007
Waterway from Lake Huron to Lake Superior	15,739,383
Waterway from Lake Erie to Lake Huron	14,751,407
Total for waterway from Lake Erie to Lake Superior	30,490,790
Lake Erie to Lake Michigan, same as waterway from Lake Erie to Lake Huron	14,751,407

On account of the irregular cutting necessary to excavate a channel to the required width and depth, no table showing locations of the various cuttings has been made. In a great many places the sides only need to be trimmed; at other places a small bar extends across the channel.

On plates 2 to 13, inclusive, side lines of the channel are shown, only where cutting is necessary for the 30-foot channel.

Respectfully submitted.

ANDREW J. SWIFT.

The BOARD OF ENGINEERS ON DEEP WATERWAYS.

APPENDIX NO. 18.

CHARACTER OF MATERIALS ON DEEP WATERWAY ROUTES.

The instructions of the Board to field parties required that borings should be made at such frequent intervals along the routes investigated as found necessary to determine the elevation of the rock surface, where above the bottom grade of the proposed waterways, and to determine the nature of the materials to be excavated, if the waterways should be constructed.

In addition to these borings, diamond-drill holes were bored through the rock strata of locations where the natural outcrop did not indicate the nature of the material to be excavated and the character of rock on which structures would have to be founded.

Samples were preserved from all the holes, and an accurate record kept of the depth from which taken.

Vertical sections of the holes along the located lines have been plotted on the profiles of the routes, and the limiting lines between different kinds of material sketched in between adjacent holes. From these sections and profiles the average limiting elevations of the bottom and top of the different kinds of materials have been estimated and compiled in the annexed tables.

The plates showing the character and thickness of the strata at diamond-drill holes are inserted in the tables in connection with the corresponding station numbers of the routes.

Respectfully submitted.

GEO. Y. WISNER.

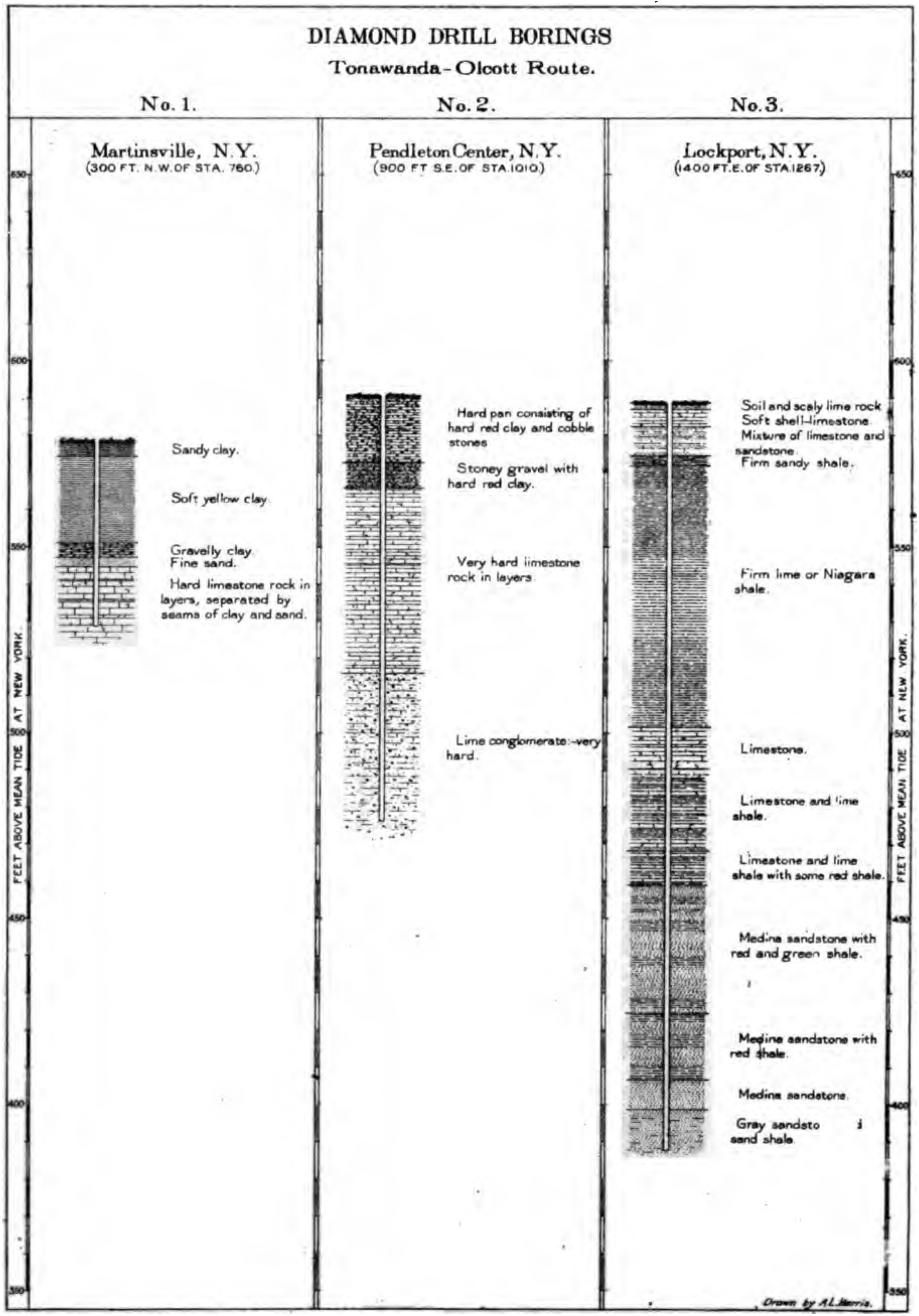
The BOARD OF ENGINEERS ON DEEP WATERWAYS.

Character of material to be excavated—Continued.

TONAWANDA-OLCOTT ROUTE.

Station.	Elevation of grade.		Elevations of different kinds of material.								
	30-foot channel.	21-foot channel.	Rock.	Hard pan and stones.	Gravel and stones.	Sand and gravel.	Clay and gravel.	Hard clay.	Soft clay.	Mud.	Mud and gravel.
−80+00 to −6+00	544.5	553.5	Corniferous limestone, 544.5 to 548.								
−6+00 to 15+00a	544.5	553.5	Corniferous limestone, 544.5 to 561.			561 to 562					
15+00 to 85+27	544.5	553.5	Corniferous limestone, 544.5 to 556.			556 to 561					Chiefly mud, 561 to 564.
85+27 to 150+00	538.5	545.5				547 to 566		538.5 to 547			Chiefly mud, 566 to 569.
150+00 to 200+00	536.0	545.0				536 to 551					
200+00 to 240+00	536.0	545.0	Salina shale, 536 to 545			545 to 550					
240+00 to 300+00	536.0	545.0	Salina shale, 536 to 538			538 to 545					
300+00 to 320+00	536.0	545.0				536 to 545					
320+00 to 360+00	535.0	544.0				535 to 537					
360+00 to 430+00	535.0	544.0				535 to 541					
430+00 to 560+00	535.0	544.0				535 to 538					
560+00 to 575+00	535.0	544.0	Salina shale, 535 to 539				539 to 542				
575+00 to 600+00	535.0	544.0				546 to 550	535 to 546				
600+00 to 640+00	535.0	544.0					535 to 538 565 to 575		538 to 565		
640+00 to 675+00	535.0	544.0			535 to 539 554 to 563		571 to 577		539 to 554 563 to 571	575 to 576	
675+00 to 720+00	535.0	544.0		535 to 550				568 to 575	550 to 568		
720+00 to 775+00	535.0	544.0	Salina shale, 535 to 539				539 to 549	570 to 578	549 to 570		
775+00 to 900+00	535.0	544.0		535 to 550				572 to 577	550 to 572		
900+00 to 990+00	535.0	544.0	Niagara limestone, 535 to 546	546 to 562				578 to 582	562 to 578		
990+00 to 1010+00	535.0	544.0	Niagara limestone, 535 to 566	575 to 584		566 to 575	584 to 589				
1010+00 to 1080+00	535.0	544.0	Niagara limestone, 535 to 575				575 to 583		583 to 590		
1080+00 to 1150+00	535.0	544.0	Niagara limestone, 535 to 573	573 to 587					587 to 593		
1150+00 to 1190+00	535.0	544.0	Niagara limestone, 535 to 596				596 to 605				
1190+00 to 1235+00	535.0	544.0	Niagara limestone, 535 to 590				590 to 601		601 to 608		
1235+00 to 1296+25	535.0	544.0	Niagara shale, 535 to 558 Niagara limestone, 558 to 595					595 to 610			
1296+25 to 1335+25	495	504	Clinton shale, 495 to 500 Clinton limestone, 500 to 525				525 to 530				
1335+25 to 1342+65	455	464	Sandstone, 455 to 490 Clinton shale, 490 to 500 Clinton limestone, 500 to 525				525 to 530				
1342+65 to 1350+05	415	424	Hard red shale, 415 to 440	440 to 470							
1350+05 to 1391+25	375	382	Soft red shale, 375 to 396		400 to 415	396 to 400					

APPENDIX 18. FIG.3.


DIAMOND DRILL BORINGS
Tonawanda-Olcott Route.
No. 1.
No. 2.
No. 3.
Martinsville, N.Y.
(300 FT. N.W. OF STA. 760.)
Pendleton Center, N.Y.
(900 FT. S.E. OF STA. 1010.)
Lockport, N.Y.
(1400 FT. E. OF STA. 1267.)
Sandy clay.
Soft yellow clay.
Gravelly clay.
Fine sand.
Hard limestone rock in layers, separated by seams of clay and sand.
Hard pan consisting of hard red clay and cobble stones.
Stoney gravel with hard red clay.
Very hard limestone rock in layers.
Lime conglomerate:-very hard.
Soil and scaly lime rock.
Soft shell-limestone.
Mixture of limestone and sandstone.
Firm sandy shale.
Firm lime or Niagara shale.
Limestone.
Limestone and lime shale.
Limestone and lime shale with some red shale.
Medina sandstone with red and green shale.
Medina sandstone with red shale.
Medina sandstone.
Gray sandsto d sand shale.
FEET ABOVE MEAN TIDE AT NEW YORK.
650
600
550
500
450
400
350
Drawn by A.L. Harris.

JULIUS BIEN & CO PHOTO LITH.

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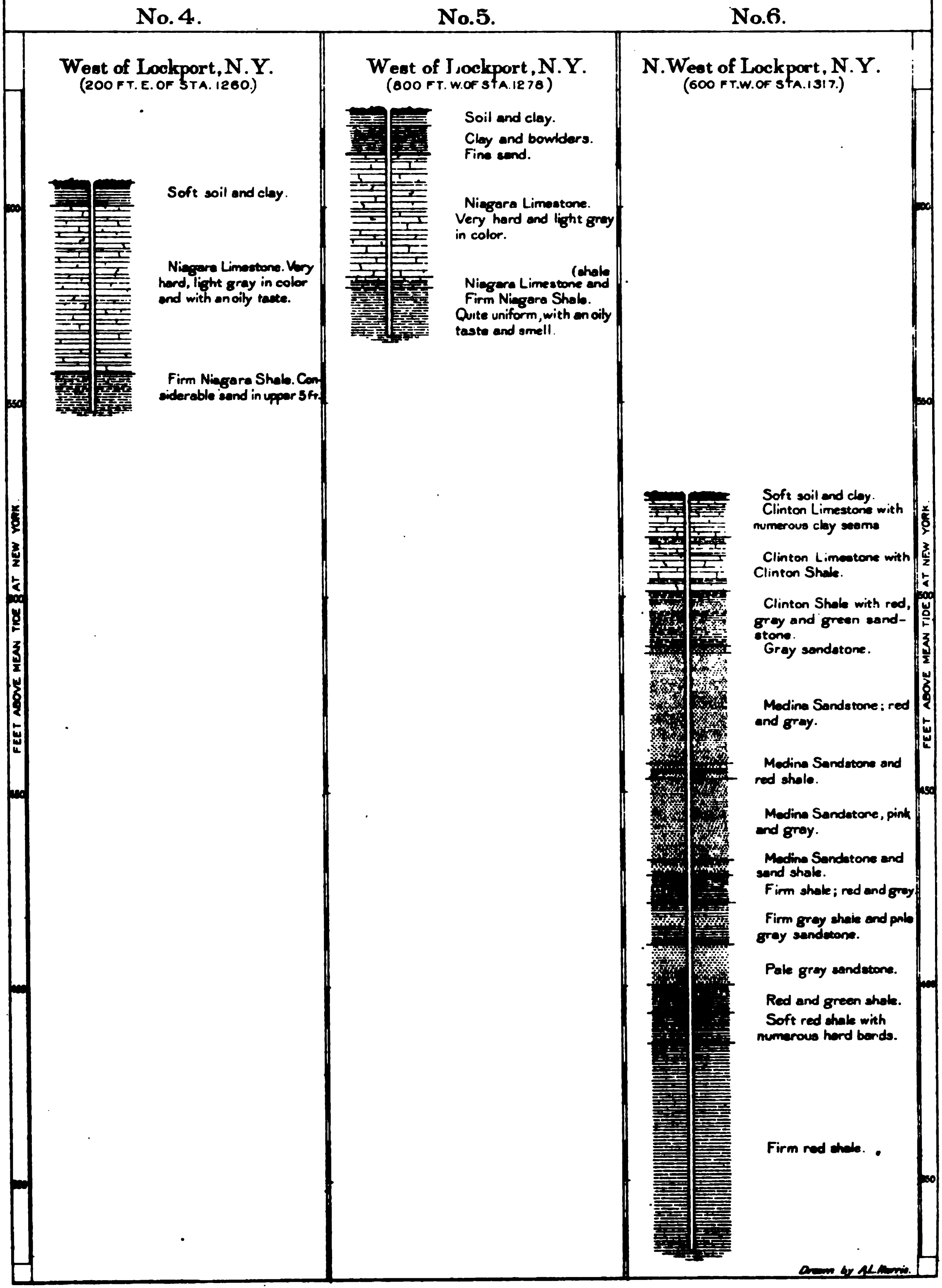
DIAMOND DRILL BORINGS

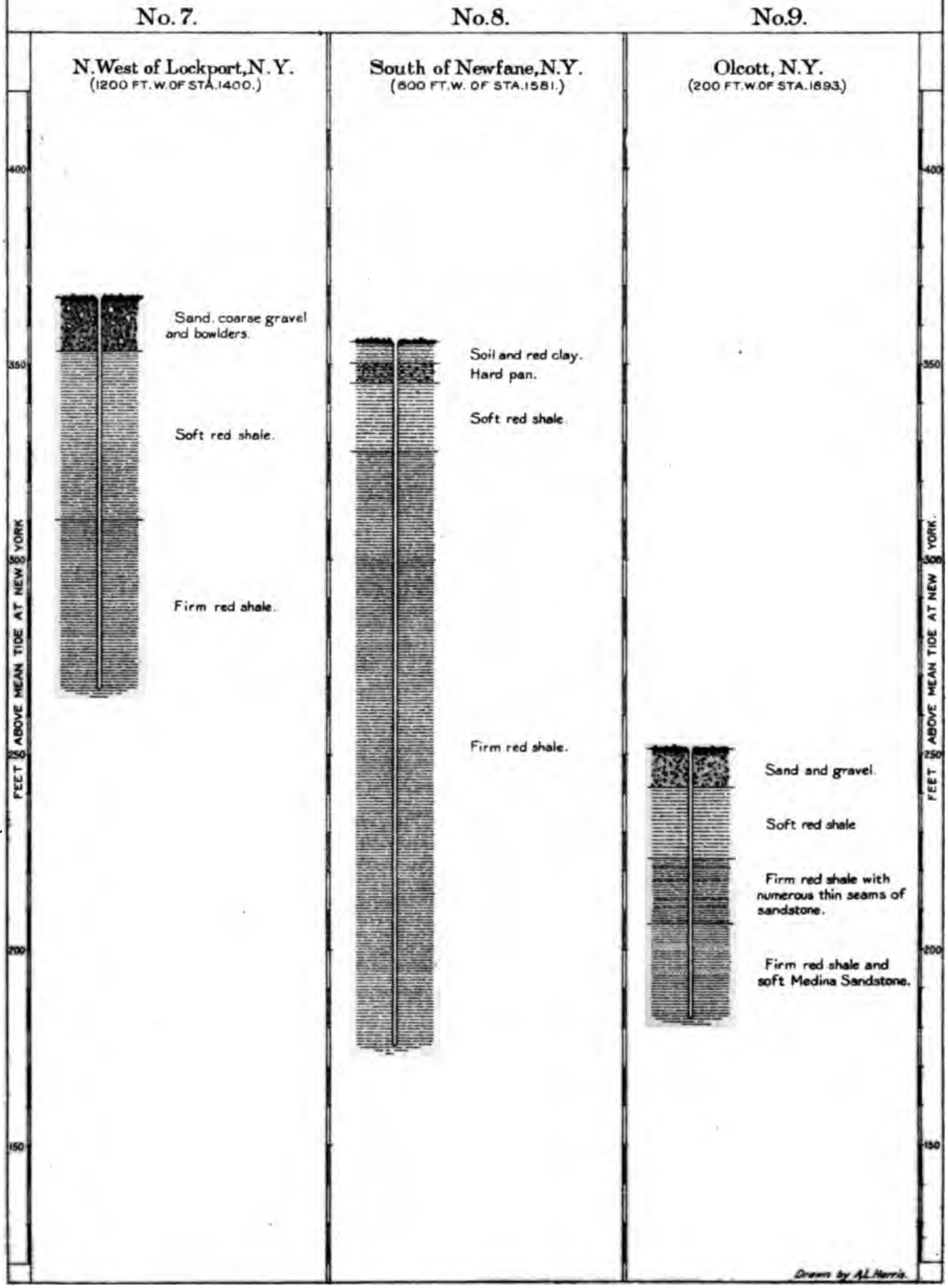
Tonawanda-Olcott Route.


No. 4.
West of Lockport, N.Y.
(200 FT. E. OF STA. 1260.)
Soft soil and clay.
Niagara Limestone. Very hard, light gray in color and with an oily taste.
Firm Niagara Shale. Considerable sand in upper 5 ft.
No. 5.
West of Lockport, N.Y.
(800 FT. W. OF STA. 1278)
Soil and clay.
Clay and bowlders.
Fine sand.
Niagara Limestone. Very hard and light gray in color.
Niagara Limestone and (shale
Firm Niagara Shale. Quite uniform, with an oily taste and smell.
No. 6.
N. West of Lockport, N.Y.
(600 FT. W. OF STA. 1317.)
Soft soil and clay.
Clinton Limestone with numerous clay seams
Clinton Limestone with Clinton Shale.
Clinton Shale with red, gray and green sandstone.
Gray sandstone.
Medina Sandstone; red and gray.
Medina Sandstone and red shale.
Medina Sandstone, pink and gray.
Medina Sandstone and sand shale.
Firm shale; red and gray
Firm gray shale and pale gray sandstone.
Pale gray sandstone.
Red and green shale.
Soft red shale with numerous hard bands.
Firm red shale.
FEET ABOVE MEAN TIDE AT NEW YORK.
600
550
500
450
400
350
Drawn by A.L. Morris.

APPENDIX 18. FIG.5.

DIAMOND DRILL BORINGS

Tonawanda-Olcott Route.


No. 7.
No. 8.
No. 9.
N. West of Lockport, N.Y.
(1200 FT. W. OF STA. 1400.)
Sand, coarse gravel and bowlders.
Soft red shale.
Firm red shale.
South of Newfane, N.Y.
(600 FT. W. OF STA. 1581.)
Soil and red clay.
Hard pan.
Soft red shale.
Firm red shale.
Olcott, N.Y.
(200 FT. W. OF STA. 1893.)
Sand and gravel.
Soft red shale.
Firm red shale with numerous thin seams of sandstone.
Firm red shale and soft Medina Sandstone.
FEET ABOVE MEAN TIDE AT NEW YORK.
400
350
300
250
200
150
Drawn by A.L. Harris.

JULIUS BIEN & CO PHOTO. LITH.

Character of material to be excavated—Continued.

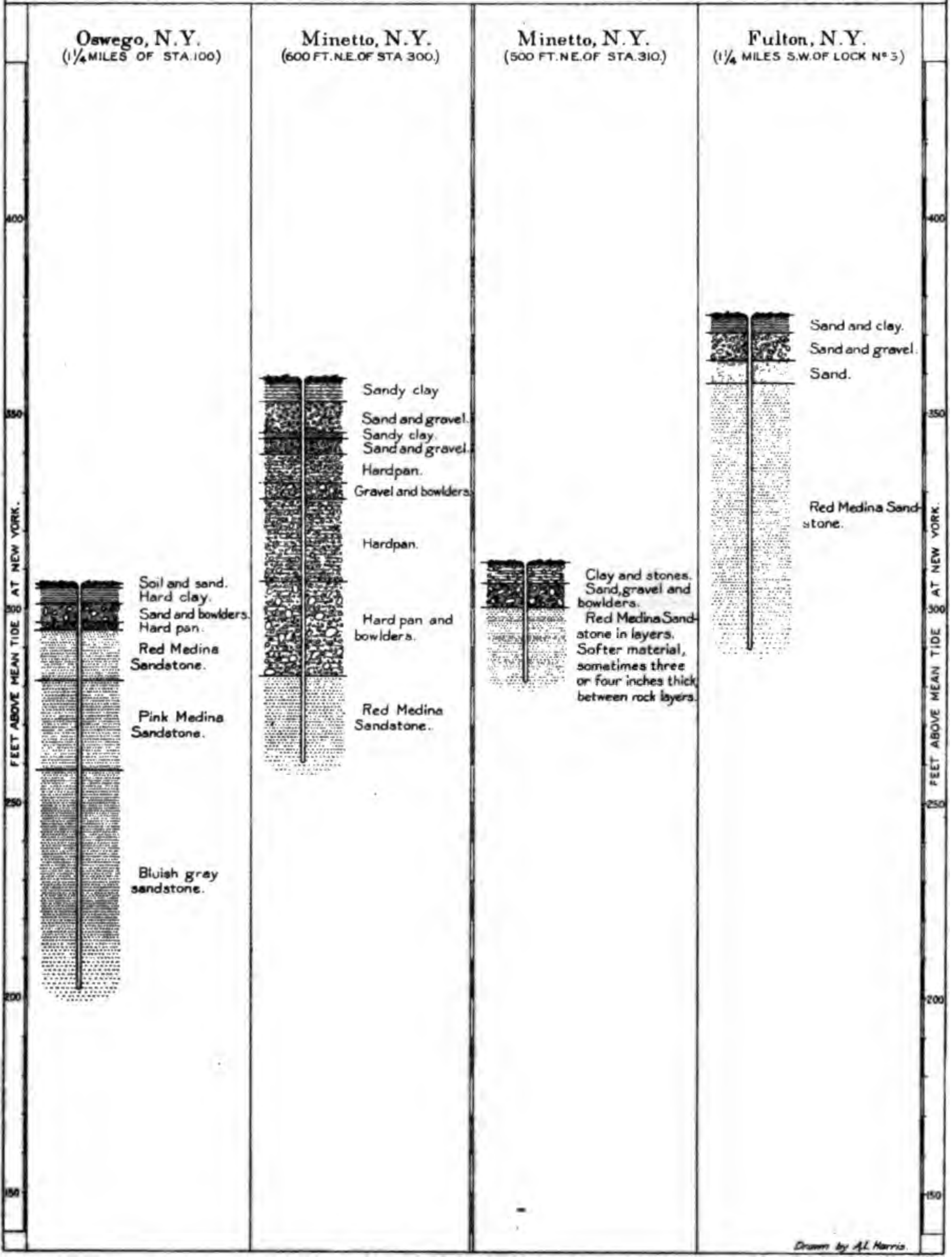
OSWEGO-MOHAWK ROUTE (WESTERN DIVISION).

Station.	Elevation of grade.		Elevation of different kinds of material.						
	30-foot channel.	21-foot channel.	Rock.	Sand, gravel, and clay.	Sand and clay.	Clay and gravel.	Sand.	Clay.	Muck or earth.
—30+00 to —(0+80)a	215.4	224.4	Argillaceous sandstone, 215.4 to 234.						
—(0+80) to —39+00	236.8	245.8	Argillaceous sandstone, 236.8 to 253.	253 to 264					
39+00 to 46+20	258.2	267.2		258.2 to 285					
46+20 to 110+50	279.6	288.6		279.6 to 310	310 to 318				
110+50 to 185+00	279.6	288.6		279.6 to 338					
185+00 to 255+00	279.6	288.6		279.6 to 308	308 to 317				
255+00 to 278+09	279.6	288.6		279.6 to 326					
278+09 to 287+00	301.0	310.0		301 to 338		338 to 355			
287+00 to 325+00	301.0	310.0	No excavation						
325+00 to 330+00	301.0	310.0			301 to 302				
330+00 to 390+00	301.0	310.0	No excavation						
390+00 to 400+00	301.0	310.0		301 to 306					
400+00 to 410+00	301.0	310.0	Medina sandstone, 301 to 306.	306 to 310					
410+00 to 425+00	301.0	310.0		301 to 302					
425+00 to 445+00	301.0	310.0		301 to 315					
445+00 to 480+00	301.0	310.0	No excavation						
480+00 to 550+00	301.0	310.0		301 to 305					
550+00 to 567+00b	301.0	310.0		301 to 343					
567+00 to 589+20	301.0	310.0	Medina sandstone, 301 to 308.	308 to 345					
589+20 to 630+00	319.0	328.0		Hard, 319 to 355					Earth, 355 to 356.
630+00 to 652+20	319.0	328.0	Medina sandstone, 319 to 331.	Hard, 331 to 355	355 to 367				
652+20 to 685+00	337.0	346.0		Hard, 337 to 380					
685+00 to 703+00	337.0	346.0	Medina sandstone, 337 to 343.	Hard, 343 to 375					
703+00 to 725+00	337.0	346.0		Hard, 337 to 347	347 to 370				Muck, 370 to 375.
725+00 to 739+20	337.0	346.0	Medina sandstone, 337 to 352.		352 to 371				Muck, 371 to 377.
739+20 to 800+00	349.0	358.0	Medina sandstone, 349 to 369.	Hard, 369 to 390					
800+00 to 870+00	349.0	358.0		Hard, 349 to 350	350 to 367				Muck, 367 to 378.
870+00 to 920+00	349.0	358.0		Hard, 349 to 365	365 to 379				
920+00 to 1120+00	349.0	358.0						349 to 366	Muck, 366 to 368.
1120+00 to 1145+00	349.0	358.0		349 to 360	360 to 375				

APPENDIX 18, FIG.6.

DIAMOND DRILL BORINGS

Oswego-Mohawk Route, Western Division.



Drawn by A.L. Harris.

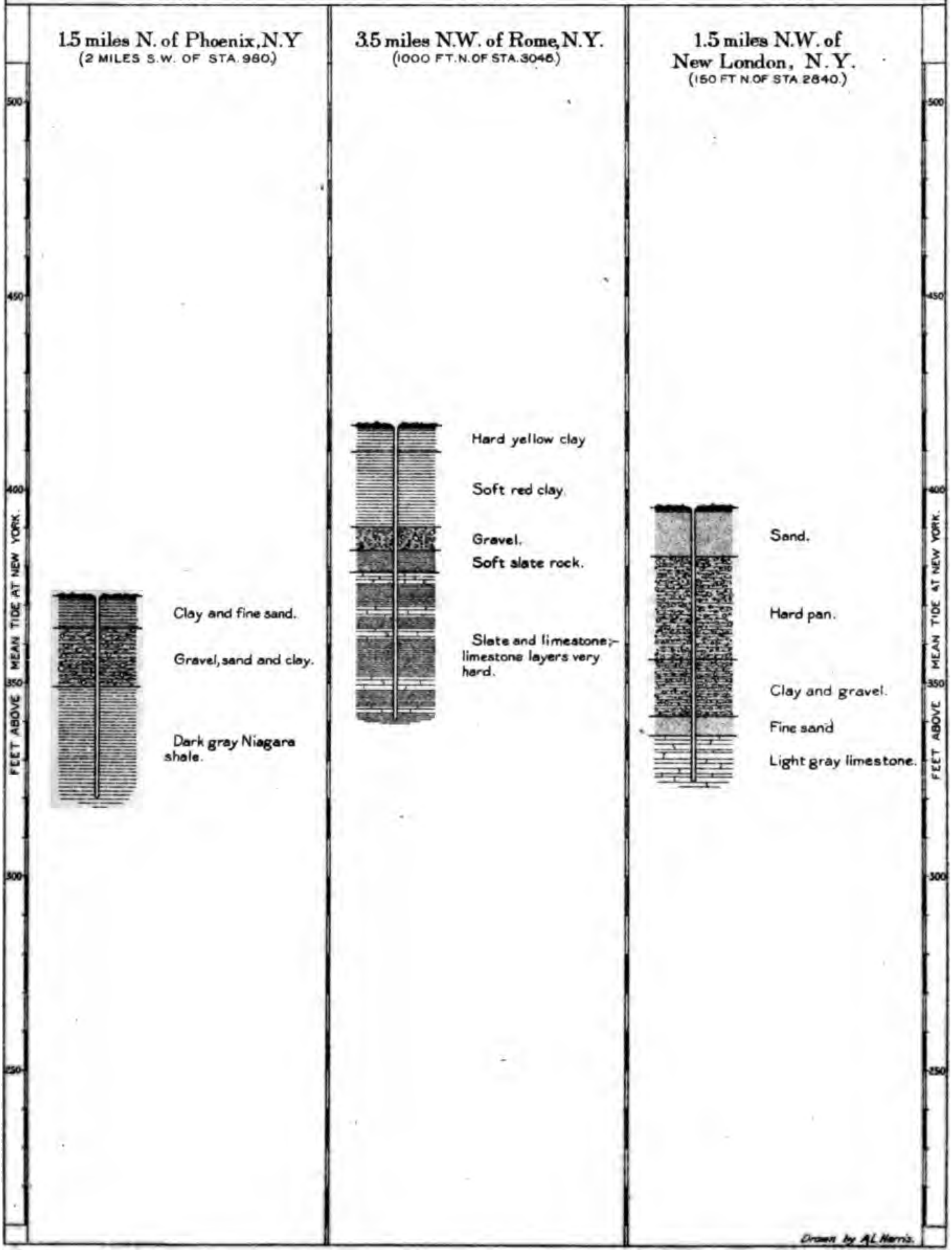
JULIUS BIEN & CO PHOTO LITH.

APPENDIX 18. FIG. 7.

DIAMOND DRILL BORINGS

Oswego-Mohawk Route, Western Division.

No. 5. No. 6. No. 7.


1.5 miles N. of Phoenix, N.Y
(2 MILES S.W. OF STA. 980.)
Clay and fine sand.
Gravel, sand and clay.
Dark gray Niagara shale.
3.5 miles N.W. of Rome, N.Y.
(1000 FT. N. OF STA. 3046.)
Hard yellow clay
Soft red clay.
Gravel.
Soft slate rock.
Slate and limestone;- limestone layers very hard.
1.5 miles N.W. of New London, N.Y.
(150 FT. N. OF STA. 2840.)
Sand.
Hard pan.
Clay and gravel.
Fine sand
Light gray limestone.
FEET ABOVE MEAN TIDE AT NEW YORK.
500
450
400
350
300
250
Drawn by A.L. Harris.

JULIUS BIEN & CO. PHOTO. LITH.

1145+00 to 1210+00	349.0	358.0		349 to 385 400 to 408	385 to 400				Muck, 408 to 410.
1210+00 to 1290+00	349.0	358.0						349 to 370	
1290+00 to 1350+00	349.0	358.0		364 to 375		Hard, 349 to 364		375 to 382	
1350+00 to 1390+00	349.0	358.0		349 to 359				359 to 365	
1390+00 to 1440+00	349.0	358.0	Shale, 349 to 355			Hard, 355 to 365		365 to 367	
1440+00 to 1460+00	349.0	358.0		Hard, 349 to 384					
1460+00 to 1600+00	349.0	358.0			349 to 355				
1600+00 to 1770+00	349.0	358.0			319 to 350				
1770+00 to 2500+00 *c*	349.0	358.0	No excavation						
2500+00 to 2600+00	349.0	358.0					349 to 371		
2600+00 to 2800+00	349 0	358.0			349 to 380			380 to 382	
2800+00 to 2905+00	349.0	358.0		Hard, 358 to 395		352 to 358	349 to 352 395 to 404		
2905+00 to 2960+00	349.0	358.0		Hard, 349 to 408					
2960+00 to 3100+00	349.0	358.0	Slate and limestone, 349 to 368.	Hard, 385 to 418		Hard, 368 to 385			
3100+00 to 3200+00	349.0	358.0	Slate and limestone, 349 to 354.		Hard, 354 to 365 Soft, 365 to 423				
3200+00 to 3265+00	349.0	358.0		Hard, 349 to 369 Soft, 369 to 428					
3265+00 to 3410+00	349.0	358.0	Slate and limestone, 349 to 377.	Hard, 377 to 400	400 to 430				
3410+00 to 3480+00	349.0	358.0		349 to 410				410 to 420	Muck, 420 to 425.
3480+00 to 3580+00	349.0	358.0		385 to 415	Hard, 349 to 385				Muck, 415 to 421.
3580+00 to 3665+00	349.0	358.0	Limestone, 349 to 364	Hard, 364 to 403 Soft, 403 to 413					Muck, 413 to 418.
3665+00 to 3785+00	349.0	358.0	Limestone, 349 to 377	Hard, 377 to 410					Muck, 410 to 413.
3785+00 to 3940+00	349.0	358.0		Hard, 349 to 390	390 to 408				
3940+00 to 4080+00	349.0	358.0		349 to 390	390 to 401				Earth, 401 to 404.
4080+00 to 4140+00	349.0	358.0		Hard, 349 to 390	390 to 400				
4140+00 to 4220+00 *d*	349.0	358.0			370 to 390			Hard, 349 to 370 390 to 398	
4220+00 to 4330+00	349.0	358.0		349 to 357			357 to 373	Hard, 373 to 398	
4330+00 to 4545+00	349.0	358.0			349 to 385				Earth, 385 to 398.
4545+00 to 4550+79	349.0	358.0	Shale, 349 to 354		354 to 377				Earth, 377 to 390.
4550+79 to 4559+00	346.0	355.0	Shale, 346 to 353		353 to 376				Earth, 376 to 381.
4559+00 to 4690+00	346.0	355.0			346 to 380				Earth, 380 to 389.
4690+00 to 4789+91 *e*	346.0	355.0			346 to 378				Earth, 378 to 385.

a Oswego Harbor *b* Fulton. *c* Lake Oneida. *d* Utica. *e* Junction of Western and Eastern Divisions at Herkimer.

Character of material to be excavated—Continued.

OSWEGO-MOHAWK ROUTE (EASTERN DIVISION).

Station.	Elevation of grade.		Elevation of different kinds of material.						
	30-foot channel.	21-foot channel.	Rock.	Gravel.	Sand and gravel.	Sand and clay.	Sand.	Clay.	Earth.
4789+91 *a* to 4830+00	346.0	355.0			360 to 374		346 to 360		374 to 380
4830+00 to 4875+00	346.0	355.0			363 to 368		346 to 363		368 to 374
4875+00 to 4900+00	346.0	355.0			360 to 366	346 to 360			366 to 371
4900+00 to 4936+20	346.0	355.0	Quartzite, 346 to 353				353 to 365		365 to 370
4936+20 to 4965+00	335.0	344.0	Quartzite, 335 to 338				348 to 362	338 to 348	362 to 370
4965+00 to 4995+00	335.0	344.0	Quartzite, 335 to 350			350 to 363			363 to 370
4995+00 to 5060+00	335.0	344.0	Quartzite, 335 to 345				345 to 355		355 to 363
5060+00 to 5120+00	335.0	344.0	Quartzite, 335 to 344				344 to 358		358 to 364
5120+00 *b* to 5159+20	335.0	344.0	Quartzite, 335 to 372						
5159+20 to 5166+60	313.5	322.5	Quartzite, 313.5 to 355						
5166+60 to 5178+00	292.0	301.0	Quartzite, 292 to 338						
5178+00 to 5250+00	292.0	301.0					292 to 312		
5250+00 to 5280+00	292.0	301.0	Shale, 292 to 300				300 to 316		316 to 325
5280+00 to 5315+00	292.0	301.0	Shale, 292 to 305				305 to 312		
5315+00 to 5365+00	292.0	301.0	Shale, 292 to 312				312 to 320		320 to 326
5365+00 to 5470+00	292.0	301.0	Shale, 292 to 305				305 to 314		314 to 320
5470+00 to 5559+20	292.0	301.0			299 to 307		292 to 299		307 to 314
5559+20 to 5585+00	270.0	279.0	Shale, 270 to 290				290 to 304		304 to 310
5585+00 to 5600+00	270.0	279.0	Shale, 270 to 280		290 to 302		280 to 290		302 to 310
5600+00 to 5615+00	270.0	279.0	Shale, 270 to 288				288 to 295		295 to 309
5615+00 to 5640+00	270.0	279.0			289 to 302		270 to 289		302 to 308
5640+00 to 5690+00	270 0	279.0	Limestone, 270 to 274		282 to 297		274 to 282		
5690+00 to 5733+00	270.0	279.0	Limestone, 270 to 277				277 to 294		294 to 298
5733+00 to 5773+00	270.0	279.0					276 to 295	270 to 276	295 to 315
5773+00 to 5830+00	270.0	279.0	Limestone, 270 to 276		303 to 310	292 to 303		276 to 292	
5830+00 to 5910+00	270.0	279.0	Limestone, 270 to 278				278 to 291		291 to 300
5910+00 to 5955+00	270.0	279.0	Limestone, 270 to 278				278 to 288		
5955+00 to 5995+00	270.0	279.0					270 to 290		290 to 297
5995+00 to 6015+00	270.0	279.0	Limestone, 270 to 273		273 to 285				
6015+00 to 6033+20	270.0	279.0	Limestone, 270 to 274				274 to 285		285 to 298
6033+20 to 6053+00	255.0	264.0	Limestone, 255 to 275				275 to 288		288 to 296
6053+00 to 6080+00	255.0	264.0	Limestone, 255 to 270				270 to 286		
6080+00 to 6110+00	255.0	264.0	Limestone, 255 to 260				260 to 283		
6110+00 to 6130+00	255.0	264.0	Limestone, 255 to 270				270 to 283		283 to 292
6130+00 to 6175+00	255.0	264.0					255 to 280		280 to 289
6175+00 to 6200+00	255.0	264.0					255 to 287		
6200+00 to 6250+00	255.0	264.0					255 to 280		280 to 293
6250+00 to 6305+00	255.0	264.0			280 to 282		255 to 280		282 to 284
6305+00 to 6335+00	255.0	264.0		255 to 274					
6335+00 to 6355+00	255.0	264.0					255 to 280		280 to 283

6355+00 to 6380+00	255.0	264.0					255 to 272		
6380+00 to 6400+00	255.0	264.0	Limestone, 255 to 256				258 to 265		
6400+00 to 6520+00	255.0	264.0					255 to 277		277 to 287
6520+00 to 6545+00	255.0	264.0					255 to 270		
6545+00 to 6560+00	255.0	264.0					255 to 283		
6560+00 to 6645+00	255.0	264.0					255 to 270		
6645+00 to 6677+20	255.0	264.0				255 to 274			274 to 287
6677+20 to 6707+00	240.0	249.0				240 to 260	260 to 275		275 to 282
6707+00*c* to 6745+00	240.0	249.0	Shale, 240 to 252			252 to 272	272 to 278		278 to 284
6745+00 to 6800+00	240.0	249.0				240 to 263	263 to 273		273 to 280
6800+00 to 6830+00	240.0	249.0	Shale, 240 to 244	255 to 263		244 to 255	263 to 270		
6830+00 to 6895+00	240.0	249.0			250 to 258	240 to 250	258 to 267		
6895+00 to 6925+00	240.0	249.0	Shale, 240 to 255		265 to 275	255 to 265			275 to 283
6925+00 to 6990+00	240.0	249.0			253 to 266	240 to 253	266 to 274		274 to 278
6990+00 to 7045+00	240.0	249.0					240 to 265		265 to 273
7045+00 to 7140+00	240.0	249.0					240 to 258		
7140+00 to 7185+00	240.0	249.0					240 to 253		253 to 260
7185+00 to 7211+20	240.0	249.0	Shale, 240 to 242				242 to 250		250 to 259
7211+20 to 7235+00	225.0	234.0	Shale, 225 to 235			235 to 250			250 to 253
7235+20*d* to 7265+00	225.0	234.0			225 to 248				
7265+00 to 7272+00	225.0	234.0	Shale, 225 to 330		230 to 242				
7272+00 to 7355+00	225.0	234.0			230 to 248		225 to 230		
7355+00 to 7430+00	225.0	234.0			225 to 247				247 to 258
7430+00 to 7455+73	225.0	234.0			225 to 233				
7455+73 to 7550+00	210.0	219.0					210 to 227		227 to 235
7550+00 to 7640+00	210.0	219.0				210 to 228			228 to 232
7640+00 to 7705+00	210.0	219.0			220 to 235			210 to 220	235 to 247
7705+00 to 7735+00	210.0	219.0		210 to 224					
7735+00 to 7775+00	210.0	219.0			210 to 227				227 to 240
7775+00 to 7820+00	210.0	219.0						210 to 230	230 to 245
7820+00 to 7860+00	210.0	219.0		210 to 226					226 to 235
7860+00 to 7915+00	210.0	219.0			210 to 229				229 to 235
7915+00 to 7935+00	210.0	219.0							210 to 213
7935+00 to 7940+00	210.0	219.0	Shale, 210 to 232						232 to 235
7940+00 to 8040+00	210.0	219.0					210 to 227		227 to 233
8040+00 to 8053+00	210.0	219.0	Shale, 210 to 262						262 to 269
8053+00 to 8090+00	210.0	219.0	Shale, 210 to 314	314 to 325			325 to 340		340 to 348
8090+00 to 8110+00	210.0	219.0	Shale, 210 to 283		283 to 320	320 to 334	334 to 342		
8110+00 to 8125+00	210.0	219.0	Shale, 210 to 235				235 to 340		
8125+00 to 8165+00	210 0	219.0					210 to 323		
8165+00 to 8265+00	210.0	219.0					210 to 288		
8265+00 to 8360+00	210.0	219.0	Slate, 210 to 227		227 to 240	255 to 270	240 to 255		
8360+00 to 8401+97	210.0	219.0			220 to 235	210 to 220	235 to 245		245 to 250
8401+97 to 8415+00	195.0	204.0				195 to 225		225 to 285	285 to 290
8415+00*e* to 8435+00	195.0	204.0				195 to 203			
8435+00 to 8483+00	195.0	204.0	No excavation						
8483+00 to 8506+97	195.0	204.0				195 to 207			
8506+97 to 8548+97	175.0	184.0				175 to 195			
8548+97 to 8556+37	155.0	164.0	Shale, 155 to 162		162 to 182		182 to 205		
8556+37 to 8575+00	135.0	144.0	Shale, 135 to 148		148 to 185		210 to 240	185 to 210	
8575+00 to 8620+00	135.0	144.0					135 to 137		137 to 138

a Junction of Western and Eastern divisions. *b* Little Falls. *c* Fonda. *d* Amsterdam, *e* Normans Kill.

Character of material to be excavated—Continued.

OSWEGO-MOHAWK ROUTE (EASTERN DIVISION)—Continued.

Station.	Elevation of grade.		Elevation of different kinds of material.						
	30-foot channel.	21-foot channel.	Rock.	Gravel.	Sand and gravel.	Sand and clay.	Sand.	Clay.	Earth.
8620+00 to 8675+00	135.0	144.0	No excavation						
8675+00 to 8695+00	135.0	144.0					170 to 200	135 to 170	
8695+00 to 8730+00	135.0	144.0	No excavation						
8730+00 to 8747+00	135.0	144.0		153 to 165				135 to 153 165 to 183	
8747+00 to 8785+00	135.0	144.0	No excavation						
8785+00 to 8825+00	135.0	144.0					165 to 178	135 to 165	
8825+00 to 8900+00	135.0	144.0	No excavation						
8900+00 to 8943+97	135.0	144.0					150 to 157	135 to 150	157 to 160
8943+97 to 8951+37	114.5	123.5					130 to 156	114.5 to 130	
8951+37 to 8958+77	94.0	103.0	Shale, 94 to 103					103 to 125	125 to 128
8958+77 to 8983+00	73.5	82.5	Shale, 73.5 to 88					88 to 130	
8983+00 to 9021+80	73.5	82.5						73.5 to 85	85 to 90
9021+80 to 9029+20	52.8	61.8	Shale, 52.8 to 130					130 to 156	
9029+20 to 9036+60	32.1	41.1	Shale, 32.1 to 145					145 to 165	
9036+60 to 9044+00	11.4	20.4	Shale, 11.4 to 100					100 to 120	120 to 130
9044+00 to 9051+40	− 9.3	− 0.3	Shale, −9.3 to −5		−5 to 20			20 to 41	
9051+40 to 9070+00	− 30.0	− 21.0	Shale, −30 to −26		−26 to −15			−15 to 10	10 to 15
9070+00 to 9106+19*a*	− 30.0	− 21.0			−30 to −17	−17 to −4			−4 to 1

a Junction with Hudson River—station 5757+00 of Hudson River survey.

Character of material to be excavated—Continued.

CHAMPLAIN ROUTE (ST. LAWRENCE DIVISION).

Station.	Elevation of grade.		Elevation of different kinds of material.							
	30-foot channel.	21-foot channel.	Rock, limestone.	Hardpan.	Sand and gravel.	Sand, clay, and gravel.	Clay and gravel.	Sand and clay.	Sand.	Clay.
Zero	215.4	224.4								
Zero *a* to 3575+00	214.4	223.4	No excavation							
3575+00 to 3590+00	213.4	222.4			Mixed with bowlders, 213.4 to 223.					
3590+00 to 3605+00	213.0	222.0	No excavation							
3605+00 to 3640+00	212.7	221.7	212.7 to 224							
3640+00 to 3655+00	212.7	221.7	No excavation							
3655+00 to 3710+00	212.7	221.7	212.7 to 219				219 to 222			
3710+00 to 3740+00	212.7	221.7					212.7 to 215			
3740+00 to 3778+57	212.7	221.7	212.7 to 218			218 to 234				
3778+57 to 3797+00	203.0	212.0	203 to 224	224 to 230						
3797+00 to 3860+00	202.0	211.0								202 to 204.
3860+00 to 3885+00	201.5	210.5		204 to 215				Mixed with bowlders, 215 to 240.	201.5 to 204	
3885+00 to 4000+00	200.0	200.0	No excavation							
4000+00 to 4020+00	199.0	208.0			Mixed with bowlders, 199 to 204.					
4020+00 to 4045+00	199.0	208.0	199 to 204	204 to 214			Mixed with bowlders, 214 to 232.			
4045+00 to 4065+00	198.0	207.0				198 to 205				
4065+00 to 4210+00	197.0	206.0	No excavation							
4210+00 to 4225+00	196.0	205.0	196 to 205		225 to 236		205 to 225			
4225+00 to 4245+00	196.0	205.0		205 to 210						196 to 205.
4245+00 to 4310+00	196.0	205.0	196 to 201		210 to 220	201 to 203	220 to 223			208 to 210.
4310+00 to 4350+00	196.0	205.0	196 to 204				204 to 212			
4350+00 to 4365+00	196.0	205.0					196 to 203			
4365+00 to 4372+38	195.7	204.7		225 to 240						195.7 to 225.
4372+38 to 4388+00	183.9	192.9	183.9 to 195	220 to 240						195 to 220.
4388+00 to 4600+00	182.0	191.0				182 to 186				
4600+00 to 4720+00	179.0	188.0	No excavation							
4720+00 to 4750+00	178.0	187.0				178 to 183				
4750+00 to 4915+00	177.0	186.0	No excavation							
4915+00 to 4930+00	175.0	184.0				175 to 180.				
4930+00 to 5010+00	175.0	184.0	No excavation							
5010+00 to 5015+00	175.0	184.0				175 to 183.				
5015+00 to 5074+60	175.0	184.0	No excavation							

a Tibbetts Point light-house, Cape Vincent.

Character of material to be excavated—Continued.

CHAMPLAIN ROUTE (ST. LAWRENCE DIVISION)—Continued.

Station.	Elevation of grade.		Elevation of different kinds of material.							
	30-foot channel.	21-foot channel.	Rock, limestone.	Hardpan.	Sand and gravel.	Sand, clay, and gravel.	Clay and gravel.	Sand and clay.	Sand.	Clay.
5074+60 to 5125+00	175.0	180.0	175 to 178	178 to 200		200 to 215		228 to 236		215 to 228.
5125+00 to 5232+60	175.0	180.0		175 to 192				217 to 227		192 to 217.
5232+60 to 5400+00	174.5	183.0		Mixed with bowlders, 174.5 to 200.			200 to 206			206 to 215.
5400+00 to 5507+88	174.5	183.5				174.5 to 188.				188 to 198.
5507+88 to 5520+00	126.8	135.8	126.8 to 129	150 to 165		129 to 150			183 to 190	165 to 183.
5520+00 to 5635+00	126.0	135.0		126 to 135		135 to 150			185 to 193	150 to 185.
5635+00 to 5670+00	124.0	133.0	No excavation							
5670+00 to 5695+00	124.0	133.0				124 to 126				
5695+00 to 5720+00	124.0	133.0	No excavation							
5720+00 to 5735+00	124.0	133.0			124 to 129					
5735+00 to 5830+00	124.0	133.0	No excavation							
5830+00 to 5860+00	124.0	133.0				124 to 127				
5860+00 to 5920+00	123.0	132.0	No excavation							
5920+00 to 5980+00	123.0	132.0				123 to 128				
5980+00 to 6220+00*a*	123.0	132.0	No excavation							
6220+00 to 6235+00	123.0	132.0							123 to 128	
6235+00 to 6270+00	123.0	132.0	No excavation							
6270+00 to 6280+00	123.0	132.0							123 to 130	
6280+00 to 6325+00	123.0	132.0	No excavation							
6325+00 to 6385+00	123.0	132.0							123 to 128	
6385+00 to 6600+00	123.0	132.0	No excavation							
6600+00 to 6700+00*b*	123.0	132.0							123 to 129	
6700+00 to 6970+00	122.0	131.0	No excavation							
6970+00 to 7010+00	122.0	131.0							122 to 124	
7010+00 to 7185+00	122.0	131.0	No excavation							
7185+00*c* to 7195+00	122.0	131.0							122 to 124	

a St. Regis. *b* Head of Lake St. Francis. *c* Junction with Champlain route, northern division.

Character of material to be excavated—Continued.

CHAMPLAIN ROUTE (NORTHERN DIVISION).

Station.	Elevation of grade.		Elevation of different kinds of material.							
	30-foot channel.	21-foot channel.	Rock.	Hardpan.	Gravel.	Sand and gravel.	Sand and clay.	Sand.	Clay.	Muck.
7195+00 to 7397+00	122.4	131.4	No excavation							
7397+00 to 7470+00	122.4	131.4							122.4 to 131	
7470+00 to 7515+00	122.4	131.4			Mixed with bowlders. 122.4 to 127.				127 to 134	
7515+00 to 7615+00	122.4	131.4	Limestone, 122.4 to 137						137 to 150	
7615+00 to 7710+00	122.4	131.4							122.4 to 148	
7710+00 to 7750+00	122.4	131.4	Limestone, 122.4 to 138						138 to 150	
7750+00 to 7815+00	122.4	131.4	Limestone, 122.4 to 153						153 to 167	
7815+00 to 7850+00	122.4	131.4	Limestone, 122.4 to 142						142 to 165	
7850+00 to 7890+00	122.4	131.4							122.4 to 159	
7890+00 to 7970+00	122.4	131.4	Limestone, 122.4 to 140	140 to 143	143 to 147				147 to 158	
7970+00 to 8000+00	122.4	131.4							122.4 to 150	
8000+00 to 8020+00	122.4	131.4	Limestone, 122.4 to 128	128 to 131	131 to 136				136 to 149	
8020+00*a* to 8110+00	122.4	131.4							122.4 to 140	
8110+00 to 8250+00	122.4	131.4							122.4 to 140	
8250+00 to 8399+00	122.4	131.4							123.4 to 138	
8399+00 to 8403+00	122.4	131.4	Limestone and quartzite, 122.4 to 124.						124 to 136	
8403+00 to 8569+00	122.4	131.4							122.4 to 138	
8569+00 to 8575+00	122.4	131.4	Limestone and quartzite, 122.4 to 128.		128 to 138				Hard, 138 to 147	
8575+00 to 8620+00	122.4	131.4							122.4 to 131 Hard, 131 to 138	
8620+00 to 8652+00	122.4	131.4			125 to 127			Hard, 122.4 to 125	127 to 130 Hard, 130 to 137	
8652+00 to 8690+00	122.4	131.4	Limestone and quartzite, 122.4 to 133.		137 to 140			Hard, 133 to 137	Hard, 140 to 146	
8690+00 to 8745+00	122.4	131.4							122.4 to 138 Hard, 138 to 144	
8745+00 to 8758+00	122.4	131.4	Quartzite, 122.4 to 134					Hard, 134 to 145	145 to 153	
8758+00 to 8773+00	122.4	131.4						Hard, 122.4 to 150	150 to 158	
8773+00 to 8820+00	122.4	131.4	Quartzite, 122.4 to 165				165 to 173			
8820+00 to 8880+00	122.4	131.4	Quartzite, 122.4 to 162				162 to 165			165 to 168.
8880+00 to 8970+00	122.4	131.4	Quartzite, 122.4 to 174				174 to 175			175 to 180.
8970+00 to 9030+00	122.4	131.4	Quartzite, 122.4 to 146		146 to 150				Hard, 150 to 152	152 to 178.
9030+00 to 9080+00	122.4	131.4	Quartzite, 122.4 to 172							172 to 182.
9080+00 to 9225+00	122.4	131.4	Quartzite, 122.4 to 165							165 to 179.

a Ormstown.

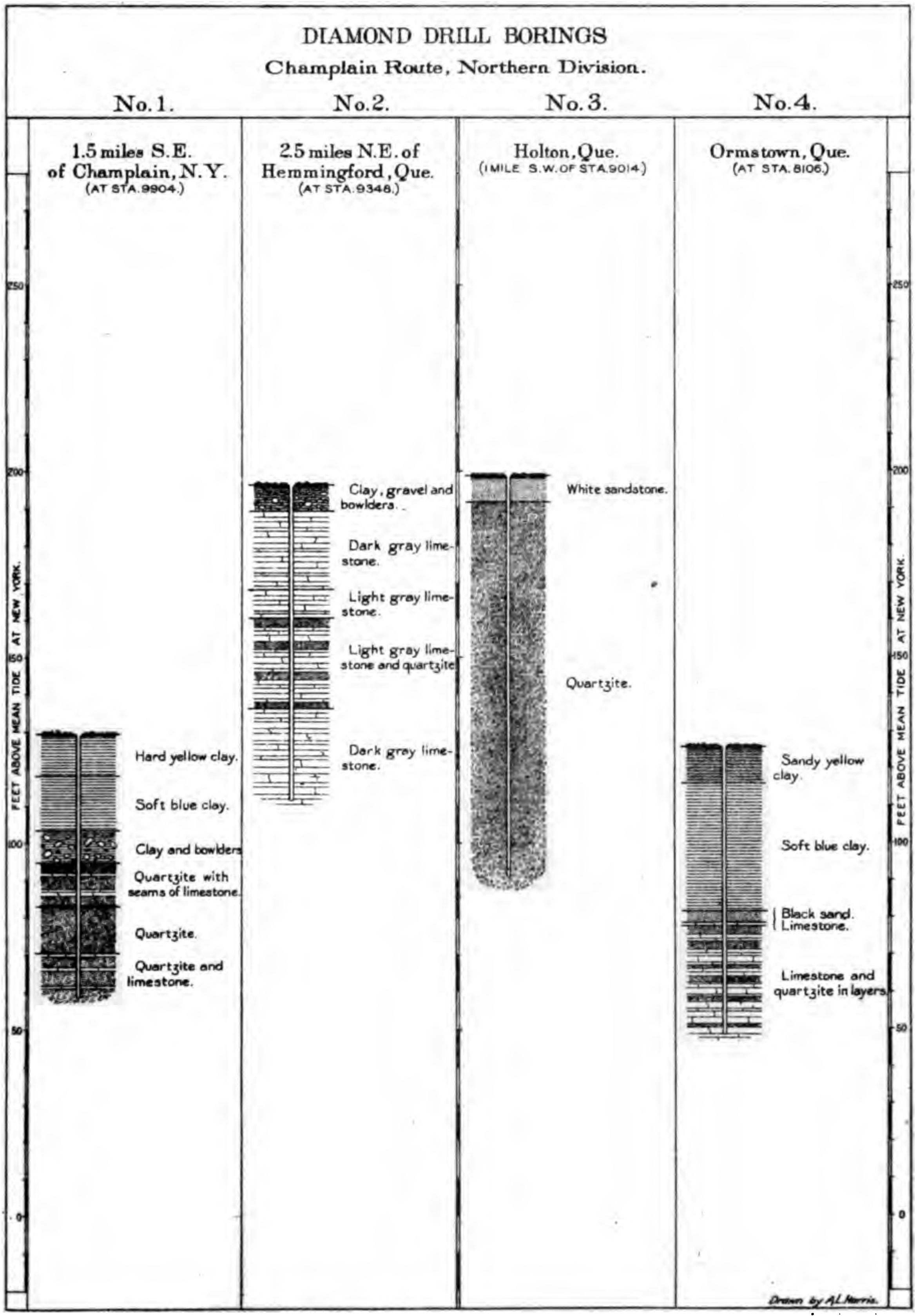
Character of material to be excavated—Continued.

CHAMPLAIN ROUTE (NORTHERN DIVISION)—Continued.

Station.	Elevation of grade.		Elevation of different kinds of material.							
	30-foot channel.	21-foot channel.	Rock.	Hardpan.	Gravel.	Sand and gravel.	Sand and clay.	Sand.	Clay.	Muck.
9225+00 to 9340+00	122.4	131.4	Limestone and quartzite, 122.4 to 180.				180 to 183			183 to 189.
9340+00 to 9480+00	122.4	131.4	Limestone and quartzite, 122.4 to 201.							201 to 207.
9480+00 to 9560+00	122.4	131.4	Limestone and quartzite, 122.4 to 187.						187 to 189	189 to 196.
9560+00 to 9685+00	122.4	131.4	Limestone and quartzite, 122.4 to 165.						165 to 173	173 to 178.
9685+00 to 9760+00	122.4	131.4	Limestone and quartzite, 122.4 to 160.						160 to 170	
9760+00 to 9792+00	122.4	131.4	Limestone and quartzite, 122.4 to 143.			143 to 150			150 to 161	
9792+00 to 9809+00	122.4	131.4				122.4 to 147			Hard, 147 to 155	
9809+00 to 9840+00	122.4	131.4	Quartzite and limestone, 122.4 to 130.			130 to 152			Hard, 152 to 158	
9840+00 to 9870+00	122.4	131.4				Mixed with bowlders, 122.4 to 140.			Hard, 140 to 154	
9870+00 to 9876+50	122.4	131.4	Quartzite and limestone, 122.4 to 131.			Mixed with bowlders, 131 to 145.			Hard, 145 to 153	
9876+50 to 9905+00	70.0	79.0	Quartzite and limestone, 70 to 114.	125 to 135		Mixed with bowlders, 114 to 125.			Hard, 135 to 145	
9905+00 to 9935+00	70.0	79.0	Quartzite and limestone, 70 to 95.		Mixed with bowlders, 95 to 101.				101 to 120 Hard, 120 to 127	
9935+00 to 9955+00	70.0	79.0	Quartzite and limestone, 70 to 88.		88 to 98				98 to 124	
9955+00 to 10005+00	70.0	79.0							70 to 117	
10005+00 to 10030+00	70.0	79.0	Quartzite and limestone, 70 to 78.						78 to 100	
10030+00 to 10090+00	70.0	79.0	Quartzite and limestone, 70 to 84.				84 to 90			
10090+00*a* to 10115+00	70.0	79.0			70 to 75				75 to 87	
10115+00 to 10150+00	70.0	79.0			70 to 75			80 to 87	75 to 80	
10150+00 to 10220+00	70.0	79.0							70 to 77	

[a] Kings Bay, Lake Champlain.

APPENDIX 18. FIG. 8.



DIAMOND DRILL BORINGS

Champlain Route, Northern Division.

JULIUS BIEN & CO. PHOTO LITH.

Character of material to be excavated—Continued.

CHAMPLAIN ROUTE (HUDSON RIVER DIVISION).

Station.	Elevation of grade.		Elevation of different kinds of material.						
	30-foot channel.	21-foot channel.	Rock.	Gravel.	Sand and gravel.	Sand and clay.	Sand.	Soft clay.	Muck.
Zero *a* to 100+00	70.0	79.0	No excavation						
100+00 to 115+00	70.0	79.0						70 to 72	
115+00 to 155+00	70.0	79.0	No excavation						
155+00 to 315+00	70.0	79.0						70 to 76	
315+00 to 470+00	70.0	79.0						70 to 78	
470+00 to 710+00	70.0	79.0						70 to 79	
710+00 to 752+00	70.0	79.0						70 to 76	
752+00 to 760+00	70.0	79.0	Shale, 70 to 72					72 to 83	
760+00 to 820+00	70.0	79.0						70 to 83	
820+00 to 930+00	70.0	79 0						70 to 75	
930+00 to 1050+00	70.0	79.0						70 to 83	
1050+00 to 1280+00	70.0	79.0						70 to 79	
1280+00 to 1500+00	70.0	79.0				70 to 90			
1500+00 to 1505+00	70.0	79.0	Shale, 70 to 72			72 to 95			
1505+00 to 1525+00	70.0	79.0				70 to 86			
1525+00 to 1537+00	70.0	79.0	No excavation						
1537+00 to 1775+00	70.0	79.0				70 to 92			
1775+00 to 1800+00	70.0	79.0				70 to 82			
1800+00 to 1860+00	70.0	79.0				70 to 96			
1860+00 to 1907+00	70.0	79.0				70 to 84			
1907+00 to 1914+00	70.0	79.0	Quartzite, 70 to 125						
1914+00 to 1952+00	70.0	79.0				70 to 94			
1952+00 *b* to 1972+00	70.0	79.0	Quartzite, 70 to 84			84 to 106			
1972+00 to 2040+00	70.0	79.0				102 to 113		70 to 102	
2040+00 to 2250+00	70.0	79.0					95 to 108	70 to 95 108 to 117	
2250+00 to 2290+00	70.0	79.0				105 to 121	90 to 105	70 to 90	
2290+00 to 2302+00	70.0	79.0	Quartzite, 70 to 90			107 to 123	90 to 107		
2302+00 to 2320+00	70.0	79.0				107 to 124	76 to 107	70 to 76	
2320+00 to 2380+00	70.0	79.0	Quartzite, 70 to 91			112 to 123	91 to 112		
2380+00 to 2405+00	70.0	79.0	Quartzite, 70 to 122			122 to 125			
2405+00 to 2428+00	70.0	79.0				108 to 120	102 to 108	70 to 102 120 to 124	
2428+00 to 2455+00	70.0	79.0	Quartzite, 70 to 75			105 to 118	85 to 105	75 to 85 118 to 125	
2455+00 to 2495+00	70.0	79.0	Quartzite, 70 to 110				110 to 121	121 to 127	
2495+00 to 2508+00	70.0	79.0				70 to 95	95 to 122	122 to 127	
2508+00 to 2524+00	70.0	79.0	Quartzite, 70 to 145		145 to 150				

a Station zero at Port Henry.

b Whitehall.

Character of material to be excavated—Continued.

CHAMPLAIN ROUTE (HUDSON RIVER DIVISION)—Continued.

Station.	Elevation of grade.		Elevation of different kinds of material.						
	30-foot channel.	21-foot channel.	Rock.	Gravel.	Sand and gravel.	Sand and clay.	Sand.	Soft clay.	Muck.
2524+00 to 2640+00	70.0	79.0				117 to 122		70 to 117 122 to 129	
2640+00 to 2740+00	70.0	79.0	Shale, 70 to 85				119 to 123	85 to 119 123 to 134	
2740+00 to 2810+00	70.0	79.0					115 to 128	70 to 115 128 to 133	133 to 137
2810+00 to 2815+00	70.0	79.0	Shale, 70 to 82				110 to 130	82 to 110	130 to 136
2815+00 to 2848+00	70.0	79.0					113 to 130	70 to 113	130 to 139
2848+00 to 2865+00	70.0	79.0	Shale, 70 to 85				118 to 127	85 to 118	127 to 140
2865+00 to 2905+00	70.0	79.0					109 to 111	70 to 109 111 to 132	132 to 142
2905+00 to 3060+00	70.0	79.0					108 to 130	70 to 108 130 to 141	
3060+00 to 3105+00	70.0	79.0					115 to 133	70 to 115	
3105+00 to 3120+00	70.0	79.0	Shale, 70 to 90				115 to 130	90 to 115	
3120+00*a* to 3213+00	70.0	79.0					114 to 131	70 to 114	
3213+00 to 3280+00	70.0	79.0	Shale, 70 to 80		103 to 115	80 to 103		115 to 117	
3280+00 to 3297+00	70.0	79.0			103 to 122		96 to 103	70 to 96	
3297+00 to 3315+00	70.0	79.0	Shale, 70 to 97		106 to 112			97 to 106	
3315+00 to 3330+00	70.0	79.0					100 to 105	70 to 100	
3330+00 to 3390+00	70.0	79.0	Shale, 70 to 102		105 to 110			102 to 105	
3390+00 to 3415+00	70.0	79.0				70 to 90	108 to 125	90 to 108	
3415+00 to 3435+00	70.0	79.0	Shale, 70 to 86		95 to 104			86 to 95	
3435+00 to 3590+00	70.0	79.0	Shale, 70 to 102				107 to 112	102 to 107	
3590+00 to 3650+00	70.0	79.0	Shale, 70 to 75			75 to 82	82 to 89		
3650+00 to 3695+00	70.0	79.0					80 to 88	70 to 80	
3695+00 to 3723+23	70.0	79.0	Shale, 70 to 90			90 to 95			
3723+23 to 3790+00	55.0	64.0	Shale, 55 to 87			87 to 93			
3790+00 to 3950+00	55.0	64.0			67 to 76	55 to 67			
3950+00 to 4045+00	55.0	64.0		60 to 65			65 to 83	55 to 60	
4045+00 to 4125+00	55.0	64.0			59 to 70			55 to 59	
4125+00 to 4175+00	55.0	64.0	Shale, 55 to 59		64 to 69			59 to 64	
4175+00 to 4235+00	55.0	64.0			70 to 73			55 to 70	73 to 77
4235+00 to 4247+00	55.0	64.0	Shale, 55 to 57	75 to 80				57 to 75	80 to 90
4247+00 to 4310+10	55.0	64.0			64 to 79			55 to 64 79 to 87	
4310+00 to 4317+00	55.0	64.0	Shale, 55 to 60					60 to 93	
4317+00 to 4360+00	55.0	64.0						55 to 87	
4360+00 to 4410+00	55.0	64.0			61 to 74	55 to 61			
4410+00 to 4435+00	55.0	64.0			55 to 78			78 to 85	

4436+00 to 4482+38	55.0	64.0	Hard shale, 55 to 75		75 to 79	79 to 88			
4482+38 to 4550+00	35.0	44.0	Hard shale, 35 to 70						
4550+00 to 4582+09	35.0	44.0	Hard shale, 35 to 54		54 to 63	63 to 65			
4582+09 *b* to 4660+00	18.0	27.0	Hard shale, 18 to 37		37 to 42				
4660+00 to 4718+09	18.0	27.0	Hard shale, 18 to 41		40 to 42				
4718+09 to 4760+00	0.0	9.0	Hard shale, 0 to 27	27 to 34		34 to 37			
4760+00 to 4920+00	0.0	9.0	Hard shale, 0 to 22				22 to 24		
4920+00 to 4995+38	0.0	9.0	Hard shale, 0 to 5	10 to 21		21 to 31	5 to 10		
4995+38 *c* to 5211+56	—15.0	—6.0	Hard shale, —15 to 1		1 to 4				
5211+56 *d* to 5360+00	—29.0	—20.0	Shale, —20 to —12		—12 to —4				
5360+00 to 5385+00	—29.1	—20.1		—19 to —10		—29.1 to —19			
5385+00 to 5440+00	—29.2	—20.2	Shale, —29.2 to —20		—17 to —7	—20 to —17			
5440+00 to 5525+00	—29.4	—20.4			—27 to —11	—29.4 to —27			
5525+00 to 5535+00	—29.5	—20.5	Shale, —29.5 to —24		—22 to —12	—24 to —22			
5535+00 *e* to 5630+00	—29.6	—20.6		*f* —29.6 to —27	—27 to —10				
5630+00 to 5645+00	—29.7	—20.7	Shale, —29.7 to —28		—28 to —15				
5645+00 *g* to 5757+00	—29.8	—20.8			—25 to —8	—29.8 to —25			

HUDSON RIVER.

5757+00 *h* to 5840+00	—29.9	—20.9			—21 to —10	—29.9 to —21			
5840+00 to 5925+00	—29.9	—20.9	Shale, —29.9 to —27		—22 to —11	—27 to —22			
5925+00 to 6005+00	—30.0	—21.0			—15 to —11		—30 to —15		
6005+00 to 6013+00	—30.0	—21.0	Shale, —30 to —27		—23 to —9	—27 to —23			
6013+00 to 6165+00	—30.0	—21.0			—22 to —10	*i* —30 to —22			
6165+00 to 6185+00	—30.0	—21.0	Shale, —30 to —22			—22 to —16	—16 to —10		
6185+00 to 6420+00	—30.0	—21.0				—30 to —28	—28 to —11		
6420+00 to 6430+00	—30.1	—21.1	Shale, —30.1 to —25			—25 to —23	—23 to —12		
6430+00 to 6620+00	—30.2	—21.2					—30.2 to —19		
6620+00 to 6700+00	—30.2	—21.2			—30.2 to —12				
6700+00 to 6880+00	—30.4	—21.4					—30.4 to —16		
6880+00 to 6910+00	—30.5	—21.5	No excavation						
6910+00 *j* to 7115+00	—30.6	—21.6					—30.6 to —19		
7115+00 to 7500+00	—30.8	—21.8	No excavation						
7500+00 to 7600+00	—30.8	—21.8					—30.8 to —24		

a Fort Edward.
b Mechanicville.
c End of Hudson River Division.
d Troy.
e Albany.
f Mixed with clay.
g Junction with Hudson River.
h Junction with Champlain and Oswego-Mohawk routes.
i Mixed with gravel.
j Hudson City.

APPENDIX No. 19.

DIAMOND-DRILL BORINGS.

DETROIT, MICH., *August 9, 1899.*

GENTLEMEN: The diamond-drill investigations to determine the nature of the rock, its degree of hardness, thickness of strata, etc., at various points along the lines of the United States deep-waterways surveys was taken up in October, 1898, and carried on without unnecessary delay until the middle of May, 1899.

In all 25 test holes were drilled, aggregating 2,461.4 feet of combined drift and rock drilling, and distributed as follows:

	Feet.
Tonawanda-Olcott route, 9 holes	1,022.9
Lasalle-Lewiston route, 5 holes	574.4
Western Division, Oswego route, 7 holes	521.6
Northern Division, Champlain route, 4 holes	342.5

The party doing the work consisted of superintendent of diamond-drill borings, at $125 per month; foreman of diamond-drill borings, at $100 per month; teamster, with team and wagon and extra wagon and water tank, at $75 or $90 per month; two laborers, at $55 per month each; night watchman, at $55 per month; the men paying their own expenses, except car fare, in moving.

The drill outfit, which was rented of the Sullivan Machinery Company, of Chicago, consisted of an S drill, capacity 500 feet, mounted on wheels for convenience in moving; a 15-horsepower portable boiler; a Blake steam pump; 12 carbons (24 carats), and the necessary equipment of rods, casing, standpipe, blank bits, tools, etc., for carrying on the work. Three hundred dollars per month rental was paid for the outfit, all parts broken or destroyed being paid for extra at the list prices of the Sullivan Machinery Company. The loss on carbon was paid for each thirty days at the rate of $36.50 per carat for all loss by wear or breakage; all stones broken or worn below 1 carat in weight being considered too small for marketable purposes, and hence to be paid for at the regular rate.

The Sullivan Company also furnished a skilled machinist and diamond setter to serve as drill foreman, but whose salary was paid by the Board.

In addition to the above equipment, a shanty for the protection of the machine and boiler, and men while working, and a derrick used in raising and lowering the drill rods, were necessary and were purchased by the Board.

For locating the position of the drill holes on the maps, and also for determining the surface elevations of the holes, a transit and stadia board were used, "stadia" or "base line" hubs of the topographical survey being used as reference points.

For the purpose of securing better core samples in the shales or softer rock an A core barrel, drilling a $1\frac{3}{16}$-inch core, was used on the S outfit, which, unless specially equipped, drills a core $\frac{15}{16}$ inch in diameter.

All the rock core secured in drilling, whether in long, unbroken pieces or badly broken up, was saved for samples. For storing and saving the core, boxes about 8 feet long and 1 foot wide were used, each box being divided into 6 compartments, each $1\frac{1}{4}$ inches square and 8 feet long, by longitudinal strips about one-half inch wide, running lengthways of the box and securely tacked to the bottom. The top of the box was put on with screws, in order that it might be easily and quickly put on or taken off at any time.

In drilling, a 10-foot core barrel was used. In case of a uniform grade of rock, not inclined to break up under pressure of the bit, a 10-foot run might be made without pulling up the rods to empty the core barrel. Generally, however, the rock broke up more or less in drilling, in which case it would often "jam" in the core barrel, and at times it became necessary to pull up and remove the core after a run of not more than 1 or 2 feet had been made. In either case the core was placed in regular order in the core box, each "run" being separated from the one preceding it by a one-half inch strip across the compartment, and on which was marked the number of the sample, thus: S No. 1, S No. 50, etc., and the "runs" following in regular succession in the boxes. On the longitudinal strips and opposite each "run" was marked the depth from and to, thus: "26.5 feet to 34.9 feet." In addition to the above markings a label was pasted at the side of each sample or run, giving the route on which the sample was taken, the number of the sample, and number of the hole and the elevations "from—to." Thus: Route, Oswego; number of sample, 6; number of hole, 1; from El., 264; to El., 257.7.

The winter of 1898-99 was unusually long and the roads exceptionally bad most of the time. Long and frequent moves, in many cases over almost impassable roads, retarded the progress of the work and added considerably to its cost. The moves by rail were also quite costly from the standpoint of time lost.

Thirty-three moves were made by teams, covering about 110 miles, fully 75 miles of which were made over bad roads. Five moves, aggregating nearly 500 miles, were made by rail during the progress of the work. Considerable delay was experienced in getting cars when wanted, but after the outfit was loaded and ready for shipment it was in every case taken through to its destination by the railroad company in charge with but little unnecessary delay.

Aside from delays in moving, but little time was lost on account of bad weather. The work was carried on inside the shanty, and if water for the boiler and pump was at hand the work did not stop on account of storm. There were two and a half days during the winter when it was too cold and stormy to haul water, and the work had to be discontinued until the storm abated.

On the following pages of this report are given the work done at the different holes. Table No. 1, page 985, gives the amounts of drift and of rock in each hole, date, and the number of hours (1) in sinking standpipe; (2) in rock drilling; (3) moving; and (4) delays. The total number of hours is based on ten hours per day, six days per week, but one day, Thanksgiving, 1898, not being counted.

A careful record of the time spent in both drift and rock drilling was kept and are given in their respective columns in the table. The time of moving is also closely given, on a basis of ten hours per day, counting the time, except Sundays, from the time the machine was ready to move from a hole until it reached the location of the next hole. All time, on a basis of ten hours per day, not spent in drilling or moving is counted in the column of delays. The amounts given are probably a little larger than should be, especially for the winter months, when perhaps nine hours to nine and one-half hours per day were more nearly the actual time put in.

Table No. 2, page 987, is a statement of the carbon losses, giving (1) approximate losses by " wear" and "breakage;" (2) kind of rock drilled and number of feet of each; (3) number of bits used; (4) average per bit; (5) average loss per foot, life of carbon, etc.

Tables Nos. 3, 4, and 5 give the total cost and cost per foot (itemized) and the drill repairs used, on (1) the Tonawanda-Olcott and Lasalle-Lewiston routes, (2) Oswego-Mohawk routes and (3) the Champlain route, respectively.

Table No. 6, page 990, is a comparison of the actual cost of the work with what would have been the probable cost by contract under the proposal of the Sullivan Machinery Company of February, 1898.

TONAWANDA-OLCOTT ROUTE.

Diamond drill hole No. 1.—Diamond drill hole No. 1, located at Sawyers Creek, New York, was the first diamond drill hole put down. The drill outfit was moved from the freight depot, Tonawanda, on October 5, 1898, and set up, and on the following day hole No. 1 was commenced. The hole was abandoned on October 8, at a depth of 49.1 feet, elevation 529 feet.

The limestone ledge was encountered here at a depth of 33.3 feet, the material above the rock being clay, with some sand and gravel. But little trouble was experienced at this hole getting down to the ledge, no stones or bowlders being encountered.

The rock was found to be a fine, light-gray, and quite hard limestone, in thin seams, which alternated with layers of clay. The 15.8 feet drilled in rock gave but about 4 feet of core samples, no pieces of which were over 4 or 5 inches in length, and most of them being one-half to 2 inches long. The layers became thinner as the depth increased, and the rock found here was of a different nature from that found elsewhere on either of the Niagara routes, in that it was lighter in color, finer grained, and lay in thinner layers. Only about 25 per cent of the core, after striking the ledge, was saved, the clay between the rock layers grinding up and washing away.

Diamond drill hole No. 2.—Diamond drill hole No. 2, located at Pendleton Center, N. Y., was commenced on October 10 and finished on October 18, at a depth of 114 feet, elevation 476.6 feet.

Considerable trouble was experienced at this hole getting down to the ledge. The drift consisted of stones and bowlders bedded in hard clay, and it required two and one-half days of hard work to get the casing down and seated on the ledge, which was found to be 24.7 feet below the surface.

The rock is a dark-gray lime conglomerate, quite hard and somewhat porous in places. Good core samples were obtained, some pieces from 12 to 18 inches in length being obtained. Only in a few places did the core break up much in drilling, fully 80 per cent of the core being saved.

A piece about one-fourth carat in weight was broken from one of the carbons in drilling this hole.

Diamond drill hole No. 3.—Diamond drill hole No. 3, located near the head of the gulf west of Lockport, N. Y., was commenced on October 19 and finished November 3, at a depth of 200.9 feet, elevation 387.9 feet.

The Niagara limestone ledge was encountered here 1.8 feet below the surface. Below the Niagara limestone, which was found to be about 15 feet thick, or at elevation 571.9 feet, Niagara shale was entered, and continued for 70 feet, elevation 501.8 feet, when Clinton limestone, alternating with layers of dark-gray shale, was encountered. Below this, or at elevation 468.5 feet, the Medina sandstones and shales were entered, and continued to elevation 387.9 feet, at which point the hole was abandoned.

The limestones, Niagara shale, and the shales found between the sandstone seams all drilled nicely, and good progress was made in them, but the sandstone seams, which were pink or gray, or mottled pink and gray in color, proved exceedingly hard. The machine had to be heavily weighted to force the bit into the rock; the carbons polished badly, and not nearly such good progress could be made.

Good core samples were obtained throughout the hole, except in the red and green shales between the sandstone layers. These ground up and washed away quite badly, so that some runs did not give more than about 80 per cent of core.

The Niagara shale broke up but little in drilling, but broke easily, transversely to the length of the section, on being removed from the core barrel. Many pieces a foot or more in length were secured, but nearly if not quite all of these were broken into shorter pieces in handling.

At a depth of 7.5 feet the flow from the pump was lost through a crevice in the ledge, and it became necessary to ream and sink the casing below it in order to regain the flow. This proved a costly operation, as two carbons, aggregating 2¾ carats weight, were broken.

A strong flow of natural gas was struck at a depth of 79 feet, but it soon exhausted.

The last 10 feet drilled in hole No. 3 was a firm, gray shale, quite different from any of the preceding shales encountered in this hole.

Diamond drill hole No. 4.—Diamond drill hole No. 4, located 1½ miles southwest of Lockport, N. Y., was commenced on November 3 and finished November 7, at a depth of 58.6 feet, elevation 548 feet.

The Niagara limestone ledge was encountered at a depth of 6 feet, and continued to depth of 48.9 feet, elevation 557.7 feet, where the Niagara shale was encountered, and penetrated to a depth of 58.6 feet, where the hole was abandoned.

Pieces of core samples as much as 2.2 feet in length were secured at this hole, good core samples being obtained throughout.

Diamond drill hole No. 5.—Diamond drill hole No. 5, located about 1½ miles west of Lockport, N. Y., was started on November 8 and finished on November 11, at a depth of 58 feet, elevation 567 feet.

Clay, sand, and gravel were found to a depth of 11.5 feet, when the Niagara limestone was encountered at a depth of 45.5 feet, elevation 579.5 feet Niagara shale was encountered. This was penetrated to a depth of 58 feet, when the hole was abandoned.

The limestone in hole No. 5 broke up badly, causing the core barrel to "jam" and making it necessary to pull up quite often and remove the core. The shale was similar to that found in holes Nos. 3 and 4, good samples being obtained.

In seating the casing at this hole it was found that the fine sand could not be shut out by the two sets of casing setting on the ledge, which seemed to be sloping. A casing bit was set with fragments of carbons and drilled into the rock a few inches, which gave a good seating.

Holes Nos. 4 and 5 were put down for the purpose of forming, with hole No. 3, the vertices of a triangle, by means of which the plane of the Niagara shale could be approximately established.

Diamond drill hole No. 6.—Diamond drill hole No. 6, located about 2 miles northwest of Lockport, N. Y., was commenced November 11 and finished November 26, at a depth of 194.3 feet, elevation 332.1 feet.

The Clinton limestone ledge was found here 1.4 feet below the surface, and continued, alternating with layers of dark-gray shale, until a depth of 25 feet was reached, when the sandstone and shales similar to those found in hole No. 3 were entered. At depth 125.1 feet the sandstone was passed through and firm red shale was encountered to a depth of 194.3 feet, when the hole was abandoned.

At 94.2 feet a firm, dark-gray shale, similar to that in which hole No. 3 was abandoned, was entered. This bed of shale was found to be about 15 feet thick, and below it another seam of extremely hard, light-gray sandstone was found. This is about 15 feet in thickness, apparently one seam, and is the last of the sandstone, the red shale being found under it.

The sandstone in hole No. 6, like that in hole No. 3, was extremely hard drilling.

Diamond drill hole No. 7.—Diamond drill hole No. 7, located about 3 miles north of Lockport, N. Y., was commenced on November 28 and finished December 6, at a depth of 99.9 feet, elevation 267.2 feet.

The drift was found to be 13.7 feet of gravel; beneath it is red shale, which continues to 99.9 feet, where the hole was abandoned. Until a depth of 70 feet was reached the shale in places was quite soft and inclined to cave. On attempting to pull up at about 70 feet it was found that loose material had caved in above the core barrel, which was larger than the rods; after raising about 3 feet the core barrel wedged, and it was found necessary to ream down to the core barrel and drill away the wedging material before the core barrel could be loosened. The casing was "churned" down until the top of the core barrel was reached, when it apparently became loosened. The jacks were then put on and the rods raised a few inches, when a rod coupling 30 feet below the surface broke. It then became necessary to ream clear to the bit before the rods became sufficiently loose to be raised with a recovering tap.

A good firm shale was found below 70 feet depth. Above 70 feet about 45 per cent of the core ground up and washed away, while below this depth only about 10 per cent of the core was lost.

Diamond drill hole No. 8.—Diamond drill hole No. 8, located about 2 miles south of Newfane, N. Y., was commenced on December 7 and finished December 13, at a depth of 180.3 feet, elevation 175.8 feet.

The red shale ledge was encountered here at 13.5 feet and continued until the hole was abandoned. About 90 per cent of the core was secured; numerous pieces, each 1 to 2 feet in length, were secured, but they broke into shorter pieces in handling.

The first serious trouble in moving was experienced in moving from hole No. 7 to hole No 8, due to deep snows and badly drifted roads, nearly all of one day being required to get outfit through.

Diamond drill hole No. 9.—Diamond drill hole No. 9, located on the beach at Olcott, N. Y., was commenced on December 14 and finished December 16, at a depth of 68.7 feet, elevation 182.5 feet.

Shale was encountered here at 9.6 feet and continued until the hole was abandoned; it was found to be similar to that found in hole No. 8, but becoming much harder as the depth increased. Seams were found in the last 10 feet drilled which closely resembled soft Medina sandstone.

A good percentage of core samples were obtained.

Another difficult move was experienced from hole No. 8 to hole No. 9 on account of deep snow drifts, through which, in places, a road had to be shoveled.

LASALLE-LEWISTON ROUTE.

Diamond drill hole No. 1.—After finishing the Tonawanda-Olcott route the drill outfit was moved to Lasalle and the work on the Lasalle-Lewiston route commenced. The roads being blocked with snow, the move, 26 miles, had to be made by rail. Three days were lost waiting for a car at Newfane, though one had been ordered three days before wanted. No unnecessary delay occurred by the car being sidetracked between Newfane and Lasalle.

The outfit was moved to location of hole No. 1, near Lasalle, N. Y., on December 22, and the hole was finished on December 26 at a depth of 49.3 feet, elevation 524.3 feet.

At hole No. 1 were found 23 feet of clay, sand, and gravel. Niagara limestone was encountered at 23 feet and penetrated to a depth of 49.3 feet, when the hole was abandoned.

One piece of core 28 inches in length was secured at hole No. 1; much of the core at this hole, however, broke up badly in drilling. Over 80 per cent of the core was saved.

Diamond drill hole No. 2.—Diamond drill hole No. 2, located about 3 miles east of Niagara Falls, N. Y., was commenced on December 26 and finished on December 30, at a depth of 68.7 feet, elevation 523.3 feet.

Niagara limestone was found at 12.6 feet and penetrated to a depth of 67.8 feet, when the hole was abandoned. Good core samples were obtained, one piece 22 inches long being secured.

Diamond drill hole No. 3.—Diamond drill hole No. 3, located on top of the ridge, three-fourths mile south of Lewiston, was commenced on December 31, 1898, and was finished on January 26, 1899, at a depth of 219 feet, elevation 385.5 feet.

Niagara limestone was encountered at 9.6 feet; then followed in succession Niagara shale at 40.8 feet; Clinton limestone and shales, 111.3 feet, and Medina sandstones and shales at 142.1 feet. The last 13 feet drilled was a firm gray shale, similar to that found at holes Nos. 3 and 6 on the Tonawanda-Olcott routes at somewhat similar elevations.

The rock here resembled closely that at hole No. 3, on the Tonawanda-Olcott route, the sandstone being extremely hard drilling.

At a depth of 194.6 feet, hole No. 3 was abandoned for the time being, the casing being left in, and hole No. 4 put down on the side of the escarpment, it being thought that the ledge would be struck there at an elevation above that at which hole No. 3 had been abandoned.

The ledge not being encountered at hole No. 4 until elevation 388.9 feet was reached, it was necessary to move back to hole No. 3 (which was done January 24, after finishing hole No. 4) and drill deeper, the hole being abandoned at 219 feet depth, elevation 385.5 feet.

Diamond drill hole No. 4.—Diamond drill hole No. 4, on shelf on the escarpment at Lewiston, was commenced January 13 and finished January 23, at a depth of 105 feet, elevation 330.6 feet.

This hole was located on a shelf of the escarpment and the surface of the ledge was found to lie much deeper than was expected. Forty-six and seven-tenths feet of clay, sand, gravel, and bowlders were drilled through before the ledge was encountered.

Very hard, gray, and somewhat broken sandstone was found at 46.7 feet, and this proved very hard and costly drilling, 4 carats weight of carbons being fractured or broken below the "1 carat" limit. Twenty-two and one-tenth feet of this sandstone was passed through, when at elevation 360 feet the red shale was entered; this was penetrated to elevation 330.6 feet when the hole was abandoned.

On attempting to pull up the 3-inch standpipe on leaving this hole it was found to be stuck tight. The pipe broke at a coupling in "jacking" and the drive shoe and 35 feet of pipe had to be left in the hole.

Diamond drill hole No. 5.—Diamond drill hole No. 5, located about one-half mile north of Lewiston, N. Y., was commenced on January 27 and finished on February 1, at a depth of 132.4 feet, elevation 209.4 feet.

Red shale was encountered at 9.1 feet and continued to 132.4 feet, when the hole was abandoned. The shale in this hole was found to be softer than the general run of red shale previously encountered, though it became quite firm the last 40 feet. Fully 75 per cent of the core above 90 feet ground up and washed away. Below this point nearly 75 per cent was saved.

OSWEGO-MOHAWK ROUTE (WESTERN DIVISION).

Diamond drill hole No. 1.—Diamond drill hole No. 1, located at Oswego, N. Y., was commenced on February 4 and finished February 13, at a depth of 105.1 feet, elevation 201.2 feet.

Under 12.8 feet of sand, clay, and hardpan at this place, red Medina sandstone was found; at 48 feet a bluish gray sandstone was encountered and this hole was abandoned at 105.1 feet. The rock in this hole was all quite hard, but, being of a uniform texture, drilled nicely. Good core samples were obtained, one piece of gray sandstone 4.5 feet in length being secured, but was broken in handling.

The move from Lewiston to Oswego was made by rail with but little delay, the car leaving Lewiston on Thursday afternoon and arriving in Oswego about noon the following day.

On account of the severe storm and cold, water could not be gotten to the hole and work at hole No. 1 had to be stopped soon after noon on February 9, and was not resumed until the morning of the 11th, when the storm abated somewhat. This was the first time lost on the work on account of bad weather.

Diamond-drill hole No. 2.—Diamond-drill hole No. 2, located at Minetto, N. Y., was commenced on February 14 and finished March 1, at a depth of 99.3 feet, elevation 259.4 feet.

Great difficulty was experienced here in getting the casing down to the ledge, on account of the great depth of sand, gravel, and bowlders that had to be passed through. After sinking the 3-inch standpipe 21.3 feet the steel drive shoe was broken off, necessitating pulling up and starting a new hole, one day being partly lost waiting for a new shoe, which came on Monday morning, having been ordered on Saturday morning.

The 3-inch standpipe became "fast" at 45 feet in the second hole here, and, rather than risk breaking the pipe again by heavy driving, it was allowed to remain at that depth, and only the 2-inch casing was sunk the rest of the way to the ledge, which was encountered at 77.4 feet, elevation 281.3 feet. Fortunately the sand and other foreign matter could be shut out with one set of casing so that the diamond bit could be put down.

Red Medina sandstone was found and was penetrated to a depth of 99.3 feet, when the hole was abandoned, the rock being similar to the red stone found at hole No. 1.

The move from hole No. 1 to hole No. 2 was one of the most difficult of the winter, owing to badly drifted roads. The boiler and machine were each mounted on runners. The boiler being quite heavy, the runners cut through the track quite often, and it was difficult to keep it from upsetting. One whole day was required in making the move, and four teams were required to take the boiler up one hill, which was badly drifted.

As rock was not found at hole No. 2 until an elevation several feet below the bed of the Oswego River at this place was reached, another diamond drill hole, No. 3, was put down about 1,000 feet upstream from hole No. 2, where there were indications that rock would be found at a higher elevation. This proved to be the case, red Medina sandstone being found at hole No. 3 at 12.4 feet, elevation 299.2 feet, and was penetrated to a depth of 31.3 feet, elevation 280.3 feet, when the hole was abandoned. The sandstone was found to be similar to that at the preceding hole. Numerous layers of clay 4 to 5 inches in thickness were found alternating with the rock seams. Only about 70 per cent of the core was saved.

Diamond-drill hole No. 4.—Diamond-drill hole No. 4, located at Fulton, N. Y., was commenced on March 4 and finished March 9, at a depth of 86.6 feet, elevation 288.8 feet.

Eighteen and four-tenths feet of drift were penetrated, under which was found red Medina sandstone in which the hole was abandoned at 86.6 feet, the rock being similar to the Medina sandstone found in the preceding holes of this route. About 80 per cent of the core was saved, numerous clay seams of 2 to 4 inches being encountered.

Diamond-drill hole No. 5.—Diamond-drill hole No. 5, located about 1½ miles south of Phœnix, N. Y., was commenced on March 10 and finished on March 11, at a depth of 52.8 feet, elevation 319.3 feet.

Dark-gray shale was encountered at 24 feet and penetrated to a depth of 52.8 feet, when the hole was abandoned. This shale was quite firm and contained numerous harder seams or "knots," in one of which a corner about one-half carat in weight was broken from one of the carbons. About 75 per cent of good core samples were obtained.

On attempting to pull up the standpipe after finishing the hole it was found to be stuck, the sand having settled around it. The pipe broke in "jacking," and 19 feet of pipe, with the drive shoe, had to be abandoned.

Diamond-drill hole No. 6.—After finishing hole No. 5 the outfit was moved to Phœnix and loaded onto a car and shipped to Rome, N. Y., for further work there, no unnecessary delays occurring in moving.

Diamond-drill hole No. 6, located 3½ miles northwest of Rome, N. Y., was commenced on March 15 and finished on March 23, at a depth of 75 feet, elevation 339.9 feet.

A broken, slaty material was found at this hole at 31.7 feet. In "churning" into this a chopping bit was broken at 36.4 feet, and it was necessary to pull up and move to get away from broken bit.

In the second hole soft, slaty material was found at 31.6 feet. After "chopping" into this about 6 feet the diamond bit was put down and the ledge penetrated to a depth of 75 feet, elevation 339.9 feet, when the hole was abandoned. The rock was found to be alternating seams of slate and limestone, the limestone bands being quite hard. Good core samples were obtained, though about 75 per cent of the core in the last 12 feet ground away. One day was lost at this hole on account of stormy weather.

Diamond-drill hole No. 7.—Diamond-drill hole No. 7, located about 2 miles northwest of New London, N. Y., was commenced on March 24 and finished on April 1, at a depth of 71.5 feet, elevation 323.8 feet.

This was another hole that gave considerable difficulty getting down to the ledge on account of the gravel and bowlders encountered.

The ledge, a fine, light-gray limestone, was found at a depth of 59.7 feet and penetrated to a depth of 71.5 feet, when the hole was abandoned. The rock was not very hard. Good core samples were obtained, though about 25 per cent of the core ground away.

At 24.4 feet what was thought at the time to be the ledge, but afterwards proved to be a limestone bowlder, was encountered. After drilling in it about 8 inches with the diamond bit, the clay was again encountered. The stone was broken up with dynamite, so that the casing might be sunk below it.

On April 3 the outfit was moved to Rome, N. Y., and on the following day loaded onto a car and shipped to Champlain, N. Y., for work on the Champlain route, northern division. A delay of one day was occasioned at Rome waiting for a car, but after leaving Rome the outfit received but one delay en route to Champlain, that being at Watertown, N. Y., where the car was set out, but was taken up by the next train and arrived in Champlain on April 6.

CHAMPLAIN ROUTE—NORTHERN DIVISION.

Diamond-drill hole No. 1.—Diamond-drill hole No. 1, located 1 mile southeast of Champlain, N. Y., was commenced on April 7 and finished April 11, at a depth of 71.4 feet, elevation 59.8 feet.

Thirty-five and two-tenths feet of soft clay were found above the ledge at this place. The rock consisted of a lime quartzite and was extremely hard drilling, the machine having to be heavily weighted to force the bit into the rock. Good core samples were obtained, less than 10 per cent of the core being lost. The carbons polished badly, and the 36.2 feet of rock drilled required two bits.

Diamond-drill hole No. 2.—Diamond-drill hole No. 2, located about 3 miles northwest of Hemmingford, Quebec, Canada, was commenced on April 14 and finished on April 19, at a depth of 85.1 feet, elevation 112.9 feet.

The move from hole No. 1 to hole No. 2 was an exceedingly difficult one on account of the deep mud, two days being required for the 14 miles and an equivalent of 14 teams for one day.

The ledge, which is of a lime-quartzite nature, was encountered at 7.6 feet and penetrated to 85.1 feet, when the hole was abandoned. The rock was all exceedingly hard drilling, the carbons polishing badly in it.

Fully 95 per cent of good core samples was obtained, many pieces being each 1 to 3 feet in length. A strong flowing spring was encountered at 60 feet.

Diamond-drill hole No. 3.—Diamond-drill hole No. 3, located at Holton, Quebec, Canada, was commenced on April 21 and finished on May 3, at a depth of 108 feet, elevation 92 feet.

Owing to an impassable swamp intervening between holes Nos. 2 and 3, the outfit was loaded on a car at Johnsons, Quebec, and shipped the rest of the way, 5 miles, by freight. The roads from hole No. 2 to Johnsons were very muddy and considerable difficulty was experienced getting through.

The set-up at hole No. 3 was made on the rock ledge, which was penetrated to 108 feet, when the hole was abandoned. The rock was quartzite from top to bottom, and was the hardest drilling found on the work. The carbons polished badly, and 5 bits were used in the 108 feet drilled.

Over 95 per cent of good core samples (one piece, 4 feet) were obtained down to 100-foot depth, when badly broken stone was entered; this ground away badly and nearly 60 per cent of the core lost.

Two carbons were broken in this broken stone; one, however, had been broken below the 1-carat limit in hole No. 4, Lasalle-Lewiston route, and had already been counted, so the loss by breakage here was about 1 carat.

Nearly two days were lost at this hole waiting for blank bits and repairs from Chicago. They were sent through in bond to La Colle, Quebec, and some time was lost in getting them from the customs officers.

Diamond-drill hole No. 4.—Diamond-drill hole No. 4, located at Ormstown, Quebec, Canada, was commenced on May 6, and finished on May 10, at a depth of 78 feet, elevation 49.6 feet.

The move from Holton had to be made by rail and one day was lost at Holton waiting for a car.

One very bad place in the road was found between the railroad and the location of hole No. 4. In order to get over it, 2-inch plank had to be secured and about 40 feet bridged. The village of Ormstown furnished the plank free of charge.

Forty-seven and nine-tenths feet of sand and soft blue clay were found at hole No. 4, above the ledge. The rock was a lime-quartzite mixture similar to that found in holes Nos. 1 and 2.

Good core samples were obtained, less than 5 per cent of the core being lost.

As soon as hole No. 4 was finished, the outfit was loaded on a car and shipped to Chicago, and the members of the crew returned to their point of starting work and disbanded.

NUMBER OF FEET DRILLED AND DISTRIBUTION OF TIME ON DIAMOND DRILL BORING WORK.

TABLE NO. 1.—*Tonawanda-Olcott route.*

No. of hole.	Depth.	Stand-pipe.	Rock.	Feet of rock reamed.	Date.		Days.	Sinking stand-pipe.	Drilling rock.	Moving.	Delays.
					Commenced.	Finished.					
	Feet.	*Feet.*	*Feet.*		1898.	1898.		*Hours.*	*Hours.*	*Hours.*	*Hours.*
1	49.1	33.3	15.8	....	Oct. 5	Oct. 8.	3¼	5	9	6	15
2	114.0	24.7	89.3	....	Oct. 10	Oct. 18	7	20	30	6	19
3	200.9	1.8	199.1	8.0	Oct. 19	Nov. 3	13¼	3	90	7	30
4	58.6	6.0	52.6	....	Nov. 3	Nov. 7	3¼	3	16	4	12
5	58.0	11.5	46.5	....	Nov. 8	Nov. 11	3¼	7	15	6	7
6	194.3	1.4	192.9	....	Nov. 11	Nov. 26	12	5	88	5	22
7	99.9	13.7	86.2	52.9	Nov. 28	Dec. 6	7	13	36	5	26
8	180.3	13.5	166.8	....	Dec. 7	Dec. 13	6	6	36	10	8
9	67.8	12.5	55.3	....	Dec. 14	Dec. 16	3	5	11	10	4
Total	1,022.9	118.4	904.5	60.9	....	....	63	67	331	59	143

In hole No. 3 the flow was lost at 7.5 feet, and it was necessary to ream 8 feet to regain flow. About 2½ carats carbon was broken in this reaming. Hole No. 7, drill rods stuck at 70.2 feet, and the casing had to be reamed to 66.6 feet before the rods became loose. The casing was "churned" down, no carbons being used.

Lasalle-Lewiston route.

No. of hole.	Depth.	Standpipe.	Rock.	Date.		Days.	Sinking standpipe.	Drilling rock.	Moving.	Delays.
				Commenced.	Finished.					
	Feet.	*Feet.*	*Feet.*	1898.	1898.		*Hours.*	*Hours.*	*Hours.*	*Hours.*
1	49.3	23.0	26.3	Dec. 17	Dec. 26	7½	5	12	53	5
2	68.7	12.6	56.1	Dec. 26	Dec. 30	4½	6	23	5	11
					1899.					
3	219.0	9.6	209.4	Dec. 31	Jan. 26	14	10	82	12	36
				1899.						
4	105.0	46.7	58.3	Jan. 13	Jan. 23	9	32	26	6	26
5	132.4	9.1	123.3	Jan. 27	Feb. 1	5	4	24	4	8
Total	574.4	101.0	473.4	....	....	40	57	167	80	86

Oswego-Mohawk route, western division.

No. of hole.	Depth.	Standpipe.	Rock.	Date.		Days.	Sinking standpipe.	Drilling rock.	Moving.	Delays.
				Commenced.	Finished.					
	Feet.	*Feet.*	*Feet.*	1899.	1899.		*Hours.*	*Hours.*	*Hours.*	*Hours.*
1	105.1	12.8	92.3	Feb. 2	Feb. 13	9½	5	42	26	22
2	99.3	77.4	21.9	Feb. 14	Mar. 1	14	80	11	15	34
3	31.3	12.4	18.9	Mar. 1	Mar. 3	2½	5	8	5	7
4	86.6	18.4	68.2	Mar. 4	Mar. 9	5	8	23	6	13
5	52.8	24.0	28.8	Mar. 10	Mar. 11	2	3	7	6	4
6	75.0	37.0	38.0	Mar. 12	Mar. 23	10	30	15	26	29
7	71.5	59.7	11.8	Mar. 24	Apr. 1	8	58	5	8	9
Total	521.6	241.7	279.9	....	....	51	189	111	92	118

On account of drive shoe to standpipe breaking at depth 21.3 feet, first location of hole No. 3 was abandoned and new hole started. First location hole No. 6 abandoned at 36.4 feet on account of a broken bit.

Champlain route, northern division.

No. of hole.	Depth.	Standpipe.	Rock.	Date.		Days.	Sinking standpipe.	Drilling rock.	Moving.	Delays.
				Commenced.	Finished.					
	Feet.	*Feet.*	*Feet.*	1899.	1899.		*Hours.*	*Hours.*	*Hours.*	*Hours.*
1	71.4	35.2	36.2	Apr. 3	Apr. 11	8	3	22	45	10
2	85.1	7.6	77.5	Apr. 12	Apr. 19	7	4	40	20	6
3	108.0	....	108.0	Apr. 20	May 3	11	0	64	25	21
4	78.0	47.9	30.1	May 3	May 12	8	5	18	35	22
Total	342.5	90.7	251.8	....	....	34	12	144	125	39

The actual time spent in sinking standpipe, rock drilling, and in moving are very closely as given, the time moving being counted on a basis of ten hours per day from the time the outfit was ready to be moved from a hole until it reached the location of the succeeding hole.

"Delays" include all time, on the basis of ten hours per day, not spent in actual drilling or moving. They are perhaps a little large, especially in the winter months, when the days were short.

Total drilled .... feet..	2,461.4
Total standpipe .... do....	551.8
Total number hours sinking standpipe	325
Average number feet per hour	1.70
Total rock .... feet..	1,909.6
Total number hours rock drilling	753
Average number feet per hour	2.53
Total number days drilling	188
Average number feet drilled per day for actual number working days...	13.1
Average number feet drilled per day, not counting time moving (152.4 days)	16.2

Five days, besides Sundays and delays in moving, were lost during the progress of the work, viz: One holiday, two and one-half days on account of storms, and one and one-half days waiting for repairs from Chicago.

TABLE NO. 2.—*Carbon losses.*

From—	To—	Wear.	Breakage.	Limestone.	Shales.	Sandstone.	Quartzite.	Number of core bits used.	Average number feet drilled per bit.
1898.	1898.	*Carats.*	*Carats.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*		
Oct. 1	Nov. 1	$3\frac{12}{64}$	3	137.8	106.9	30.0	....	3	91.6
Nov. 1	Dec. 1	$1\frac{21}{64}$	½	90.9	164.7	65.0	....	2	161.8
	1899.								
Dec. 1	Jan. 1	$\frac{41}{64}$	....	82.4	309.2	....	....	1	391.6
1899.									
Jan. 1	Feb. 1	$5\frac{18}{64}$	4	53.4	240.8	67.1	....	4	90.3
Feb. 1	Mar. 1	$\frac{32}{64}$	....	....	29.7	114.2	....	2	71.9
Mar. 1	Apr. 1	$1\frac{8}{64}$	½	49.8	28.8	87.1	....	1	165.7
Apr. 1	May 1	$2\frac{29}{64}$	....	30.1	....	....	151.7	7	28.0
May 1	May 12	$\frac{53}{64}$	1	....	....	....	70.0	2	35.0
Total........		$16\frac{6}{64}$	9	444.4	880.1	363.4	221.7	22	86.9

The amounts of wear and of breakage in the above table are approximate, only the total loss at each weighing being definite.

Total number feet of rock drilled, including 8 feet of reaming at hole No. 3, Tonawanda-Olcott route .... feet..	1,917.6
Total carbon loss ($25\frac{6}{64}$ carats at $36.50)	$915.91
Average loss of carbon per foot of rock drilled (0.001307 carat) . per foot..	$0.477
Average loss (wear) of carbon per foot of rock drilled (0.000838 carat), per foot	$0.306
Average weight per stone of carbons furnished for the work.... carats..	2.136

Average life per stone of 2.136 carats, 163.5 feet or 76.5 feet per carat.

The greatest number of feet of rock drilled without resetting carbons was 310 feet of shale and 81.6 feet of limestone—total, 391.6 feet—on the Tonawanda-Olcott and the Lasalle-Lewiston routes.

The least amount drilled without resetting the carbons occurred at hole No. 3, on the Champlain route, where one bit drilled but 15.4 feet, another bit drilling in the same hole 15.6 feet.

TABLE NO. 3.—*Cost of diamond drill borings, repairs, etc.*

LASALLE-LEWISTON AND TONAWANDA-OLCOTT ROUTES.

Item.	Total cost.	Cost per foot.
Rental	$1,230.00	$0.769
Carbon	675.81	.423
Labor	875.64	.542
Teamster	299.00	.124
Teaming (extra)	112.25	.077
Superintendence	512.60	.321
Repairs	66.65	.042
Coal	63.38	.039
Lumber	57.49	.030
Core boxes	24.60	.015
Freight and express	66.40	.042
Traveling expense	67.08	.042
Sundries	44.06	.028
Total	4,094.96	2.494

Total number feet drilled, 1,597.3.

Item "Repairs" consisted of:

10 blank core bits, at $1.25	$12.50
1 bevel core shell	5.00
1 straight core shell	3.25
1 split-ring core lifter	3.15
2 Cossette core lifters, at $3.80	7.60
1 Reamer face	2.50
4 rod couplings, at $1	4.00
1 water swivel	8.00
1 casting for safety clamp	3.50
1 3-inch drive shoe	7.00
35 feet 3-inch drive pipe, at 29 cents	10.15
Total	66.65

Item "Lumber" consists of material for shanty 12 by 18 by 7½ feet, with flooring, and 3 to 6 by 6 inch by 33-foot pine timbers for derrick.

Soft coal used, 44,735 pounds; average price per ton, $2.83.

Number of pounds of coal per foot drilled, 28.

In addition to above items of cost there were, at close of work, freight charges amounting to $113.40, and $63.12 traveling expenses for return of outfit and men. Dividing this equally per foot drilled on whole work, the cost of work on above lines is increased $0.072 per foot, making total cost per foot $2.566.

While engaged on these lines the Sullivan Company replaced the following "worn" parts: Sixteen feet steam hose, 4 pump valves, 1 brass lining for pump cylinder.

TABLE No. 4.—*Cost of diamond drill borings, repairs, etc.*

OSWEGO-MOHAWK ROUTE, WESTERN DIVISION.

Item.	Total cost.	Cost per foot.
Rental	$600.00	$1.150
Carbon	72.43	.139
Labor	530.00	1.016
Teamster	180.00	.345
Teaming (extra)	92.50	.177
Superintendence	250.00	.479
Repairs	52.50	.101
Coal	34.25	.066
Core boxes	5.10	.010
Freight and express	74.60	.143
Traveling expenses	30.27	.058
Sundries	28.31	.054
Total	1,949.96	3.738

Total number feet drilled, 521.6.

"Repairs" on above line consisted of—

3 blank core bits, at $1.25	$3.75
2 3-inch drive shoes, at $7	14.00
19 feet 3-inch drivepipe, at 29 cents	5.51
1 straight core shell	3.25
1 cosette corelifter	3.80
2 3-inch chopping bits, at $5.75	11.50
1 double-edge chopping bit	6.25
1 rod coupling	1.00
8 feet 2-inch casing, at 43 cents	3.44
Total	52.50

Soft coal was used, 22,430 pounds; average price per ton, $3.055.

Number of pounds of coal per foot drilled, 43.

Adding $0.072 per foot for return of outfit and men at completion of work gives total cost per foot drilled $3.810.

While engaged on this line the Sullivan company replaced the following "worn" parts: One brass lining for pump cylinder, 1 piston rod for pump, 6 fire grates for boiler, 1 copper strainer for suction hose, 16⅔ feet water hose, 12 feet steam hose.

TABLE No. 5.—*Cost of diamond-drill borings, repairs, etc.*

CHAMPLAIN ROUTE, NORTHERN DIVISION.

Item.	Total cost.	Cost per foot.
Rental	$376.45	$1.099
Carbon	167.67	.490
Teamster	126.00	.368
Teaming (extra)	65.25	.190
Labor	351.17	1.024
Superintendence	187.50	.547
Repairs	24.65	.072
Coal and wood	25.17	.073
Core boxes	6.80	.020
Freight and express	77.30	.225
Traveling expenses	68.78	.201
Sundries	18.57	.057
Total	1,496.31	4.366

Total number of feet drilled, 342.5.

"Repairs" on above line consisted of—

9 blank core bits, at $1.25	$11.25
1 casting for safety clamp	3.50
2 casing bits, at $3	6.00
1 rod coupling and 1 foot rod	2.90
1 sand pump	1.50
1 ½-gallon oil can	.50
Total	24.65

Soft coal was used, 2,390 pounds; average price per ton, $4.75.

Six cords hard wood used; average price per cord, $3.25.

Adding $0.072 per foot for return of outfit and men at completion of work gives total cost per foot drilled $4.438.

TABLE NO. 6.—*Cost of diamond-drill borings compared with probable cost had work been done by contract.*

Item.	Total cost.	Cost per foot.	Probable cost by contract.	
			Total.	Per foot.
Rental	$2,206.45	$0.896		
Carbon	915.91	.372		
Repairs	154.10	.062		
Labor	1,756.81	.714		
Teamster	605.00	.246	$605.00	$0.246
Teaming (extra)	270.00	.109	270.00	.109
Superintendence	950.10	.390	950.10	.390
Coal and wood	122.80	.050		
Lumber	57.49	.023		
Core boxes	36.50	.014	36.50	.014
Freight and express	331.70	.135	281.70	.106
Traveling expenses	229.25	.093	229.25	.093
Sundries	81.64	.033		
383.8 feet rock, at $3.25[a]			1,247.35	[b]2.406
2,077.6 feet rock, at $2.25			4,674.60	
Total	7,717.75	3.137	8,274.50	3.364

[a] In the above estimate it is assumed that 130 feet of the sandstone on the Tonawanda-Olcott and the Lasalle-Lewiston routes, also all the rock on the Lake Champlain route is harder than "Niagara limestone." It is possible that some of the sandstone on the Oswego-Mohawk route would also have been classed as harder than "Niagara limestone," but it is not so treated in the above estimate.

[b] Average.

If the 60.9 feet of rock reamed in holes Nos. 3 and 7, Tonawanda-Olcott route, and the 57.7 feet of extra drift drilled in holes Nos. 2 and 6, Oswego-Mohawk route, be counted, then the total number of feet drilled is 2,580 feet, and the cost per foot $2.914.

The "probable cost by contract" is based on a proposition made by the Sullivan Machinery Company in February, 1898, in which they offered to drill all rock not harder than Niagara limestone for $2.25 per foot, but on all harder grades of rock (than Niagara limestone) a price of $3.25 to be charged. In addition, the Board to furnish water for the boiler and pump, pay for moving outfit from place to place, except freight charges to and from place of beginning work, and the cost of superintendence would also have to be allowed by the Board.

The freight charges, approximately, on outfit from Chicago to Tonawanda and return are deducted in determining "probable cost" by contract."

Respectfully submitted.

R. C. SMITH,
Superintendent Diamond Drill Borings.

The BOARD OF ENGINEERS ON DEEP WATERWAYS.

APPENDIX NO. 20.

PRECISE LEVELS ALONG ST. LAWRENCE RIVER AND LAKE ST. CLAIR.

DETROIT, MICH., *November 30, 1899.*

GENTLEMEN: I have the honor to submit the following final report on precise level work along St. Lawrence River from St. Regis to Tibbetts Point, N. Y., and along Lake St. Clair from Grossepoint to New Baltimore, Mich., performed by me between July 11, 1898, and July 6, 1899.

The St. Lawrence River levels were paid for by the United States Board of Engineers on Deep Waterways, and the Lake St. Clair levels were carried out under the United States Lake Survey in connection with a special project for the investigation of lake levels.

The instrument outfit was furnished by the Lake Survey, and consisted of a new precise level purchased expressly for this work and Lake Survey level rods 1 and 5, which were slightly altered and adapted to steel-pin turning points instead of the old style footplates formerly used.

In accordance with orders from the United States Board of Engineers on Deep Waterways I was directed to establish 18 water gauges at assigned points on St. Lawrence River, and after observing water levels for a period of ten days by gauge readings taken every ten minutes between 6 a. m. and 6 p. m. These gauges were to be connected by a duplicate line of precise levels. Permanent bench marks were to be established at least 3 miles apart and in all towns or settlements along the line.

In accordance with orders from the officer in charge of the United States Lake Survey the duplicate precise level lines Gibraltar-Grossepoint and New Baltimore-Fort Gratiot, Mich., run by Mr. O. W. Ferguson for the United States Board of Engineers in 1898, were to be connected by a duplicate precise level line along Lake St. Clair from Grossepoint to New Baltimore.

Between July 13 and 16, 1898, the party was organized at Ogdensburg, N. Y., gauge boards were graduated, and preparations for placing all permanent bench marks were completed.

From July 18 to 23, 1898, 61 permanent bench marks were placed and described and the 18 water gauges were established.

During the period from July 25 to August 8, 1898, the 18 water gauges were twice referenced to temporary bench marks, and gauge readings were taken at ten-minute intervals for the ten days from July 27 to August 6.

On August 9, 1898, the instrumental constants were determined on a carefully measured 100 m. base line in Ogdensburg, N. Y., and on the following day the party proceeded to Hogansburg to commence leveling operations.

Leveling was continuously carried on from August 11 to November 27, 1899, between St. Regis and Alexandria Bay, New York; from May 4 to June 2, 1899, between Alexandria Bay and Tibbetts Point, New York and from June 10 to July 8, 1899, between Grossepoint and New Baltimore, Mich. The field notes of the St. Lawrence River work were rechecked and compiled between November 28 and December 16, 1898, and between June 6 and 9, 1899. The Lake St. Clair levels were compiled and tabulated by Mr. Amos F. Everett between July 10 and 28, 1899.

The party consisted of Mr. Murray Blanchard, recorder; Messrs. Amos F. Everett and Harry Wild, rodmen, and Mr. Herbert F. Briggs, umbrellaman, with myself as observer. During the season of 1899 Mr. A. H. Horton was rodman in the place of Mr. Wild, and Mr. Harry Beauvais was umbrellaman on the Lake St. Clair work.

I take this opportunity of expressing my sincere thanks to the members of my party for the faithful and efficient services rendered. In all this work there was not one failure to close a stretch which could be attributed to a misreading of a rod, an error of recording, or careless rodding. Each man was expert in performing his duties and knew and appreciated the relation of his own work to the work as a whole. To this, and especially to the ardent labors of Messrs. Blanchard, Everett, and Horton, may be largely attributed the rapid progress and successful prosecution of the work. The high degree of accuracy attained in this work is due to the extreme patience, eternal vigilance, and careful study of the observer and the methods employed.

As the orders were free from all restrictions relating to methods, I was free to act in accordance with my own views and experience, and as a result devised a method of precise leveling which is believed to be the best now in use. This method, together with a description of the instruments used and some statistics of results and cost, will be briefly given in the following:

1. DESCRIPTION OF INSTRUMENTS.

The level used is known as Buff & Berger precise level No. 2768, and is one of six instruments built in 1897–98, essentially after the design by Prof. T. C. Mendenhall, president of the Worcester Polytechnic Institute.

The entire instrument is made of bronze, except the telescope collars and the vertical spindle, which are of hard steel. The telescope is supported on four agate points by a cradle, pivoted at the center of the instrument, which latter is supported on a very substantial tripod by three leveling screws. The striding level is loosely held in position by lateral guides. Two small tubular levels, set at right angles to each other, serve for quick leveling of the instrument, and the level tube is centered for each rod, reading by means of the fine micrometer, which acts on the cradle. The striding level is chambered at one end, thus making the length of the bubble adjustable. A mirror, revolving about a horizontal axis over the center of the level tube, enables the observer to read the bubble for both positions of the level tube without removing his eye from the telescope.

The properties of this instrument, as received from the maker, were as follows:

Focal length of objective	mm	402
Diameter of objective	do	38
Magnifying power of telescope	diameters	50
Ratio of telemeter threads		1:100
Value of level tube per 2 mm. division	seconds	5
Weight of instrument	kilograms	5.3
Weight of tripod stand	do	7.6

During the season of 1898 the following objectionable features were discovered in this instrument:

The thread interval was far too large to permit of sharp focusing on all three threads, thus making the readings on the extreme threads much less reliable than those on the middle thread.

The coarseness of the level tube proved to be a decided disadvantage, as the bubble did not indicate the true pointing of the telescope only when absolutely at rest, a condition requiring great care and considerable loss of time to acquire. This circumstance limited the length of shot to about 50 meters, and even under very favorable weather conditions longer sights could be taken only with the utmost care. Also, the angular position of the mirror was not adjustable, thus causing a certain parallax of the bubble image, which, however, was constant for all readings.

The stop device for the telescope was quite poor and did not permit of adjusting the threads so that these would be horizontal for both the normal and inverted positions of the telescope. The agate supports of the telescope suggested some danger of wearing the steel collars, and it appeared desirable to reverse this condition by replacing the former by soft brass points, thus throwing the wear on the supporting points instead of the collars.

These objections were all remedied by various minor alterations suggested by the writer and executed by Messrs. C. L. Berger & Sons, by Boston, in April, 1899. The thread interval was made 1:200, an adjustable stop device was attached to the telescope, the inclination of the mirror was made adjustable, and the agate points were replaced by brass points. A new level tube of 2.23 seconds per 2 mm. was imported directly from Mr. Adolf Pessler, of Braunschweig, Germany, and is now used in place of the 5-second tube. With these alterations, the instrument is at this time considered the finest precise level in the world.

The rods used were the old United States lake survey rods 1 and 5, graduated into 30-decimeter divisions, each one of which is again divided into centimeter divisions, consisting of a double row of alternating black and white centimeter squares. These rods were made some twenty years ago by Kern & Co., of Aaran, Switzerland, and in consequence of much hard usage are now in rather bad condition.

The centimeter graduation is considered by far too large to permit of estimating rod readings with an accuracy equal to the attainable accuracy of pointing with such a fine instrument, and for this reason the old rods are considered entirely out of keeping with the instrument. To accomplish good results with the old Kern rods requires most extraordinary and painstaking exertion on the part of the observer. It is a science to estimate rod readings correctly, and after all my past experience I feel confident in saying that no one has as yet mastered this science to the degree necessary to reduce the allowable error of estimation to an amount so small that it falls within the error of pointing of the instrument. Yet this is necessary if the rod readings shall be as accurate as the instrument pointings permit.

It is not intended here to criticise the self-reading principle for precise-level rods. On the contrary, the advantages of self-reading rods over target rods are so apparent as to preclude the use of the latter on economical high-grade work.

All the disadvantages found to exist in the present style of lake-survey rods with centimeter graduations have been remedied in a new pattern of self-reading rod designed by the writer, in which the smallest division is 2 mm., enabling the observer to estimate tenths of a division, or 0.2 mm., with 50 diameters magnifying power at a distance of 60 m. This is an accuracy quite equal to the accuracy of pointing with a 2-second level tube.

The purchase of a pair of rods built after this new pattern has been strongly urged, and would involve an expenditure of about $150.

The turning point used on this work consists of a steel pin with an enlarged head provided with a socket into which the square-ended pin of the rod fits loosely. The base of the socket is hemispherical and always affords a proper surface to hold on. The socket prevents the rods from sliding off and also protects the surface held on, when the pin is being driven into the ground. The body of the pin is about 10 inches long and 1 inch in diameter, and is quite similar to the pin originated by Mr. O. W. Ferguson some years ago. The head differs from Mr. Ferguson's design. This form of turning point gave most excellent satisfaction, and made each point held on about as secure as a temporary bench.

2. BENCH MARKS.

Permanent bench marks were made by cementing a one-fourth-inch brass bolt, 4 to 8 inches long, into bed rock or good foundation masonry of substantial public buildings. When neither of these conditions could be fulfilled, a subterraneous concrete base was constructed, generally about 1½ feet in diameter and about 2½ feet high, with its top 1½ to 2 feet below the natural surface. A similar round-headed brass bolt was set vertically into the center of this base, allowing only the rounded head to remain above the concrete surface. In all cases where it was possible, the brass bolt was set vertically and the upper end was made hemispherical. When vertical bolts could not be employed, the mark consisted of a center punch mark in the end of a square-ended bolt cemented horizontally into the masonry of a building. In all cases the letters U. S. and the name or number of the bench were cut into the stone or concrete, so as to prevent any possibility of mistaken identity.

Temporary bench marks consisted of 60-penny wire spikes driven vertically into solid and properly prepared roots of large trees. Large bowlders were always used when available, and the mark was made by working a small hemispherical knob into a suitable surface and inclosing same by a small square. The numbers of all such benches were cut into the stone or tree with a cold chisel and many of them are as good as permanent benches.

3. THE SOURCES OF ERROR.

The ultimate aim in precise leveling, as the term implies, is to perform leveling which shall be as free from errors as is attainable by the highest human skill and ingenuity combined with the most perfect leveling instruments.

There are many errors to which the process of leveling is subject, though on ordinary work they receive little or no attention, and the attainable accuracy is supposed to depend entirely on the instrument and its capability to remain in adjustment. In reality, however, it depends on the fineness of the instrument and the "knowing how," on the part of the observer, to eliminate all errors from the work, none of which can be completely eliminated by the most careful adjustment of the most elaborate and delicate instrument.

It is not intended here to give a treatise on the theory of errors, but merely to point out the various sources of error and the means for their prevention, thus justifying the methods adopted for this work.

The errors may be divided according to their causes into six general classes, viz: (1) Those resulting from the attraction of the sun and moon and those due to the spheroidal shape of the earth; (2) level-tube errors; (3) telescope errors; (4) errors produced by the level rods; (5) atmospheric influences, direction of line, and time of day, and (6) personal errors.

1. The errors of the first class are of a comparatively constant nature and are generally quite small, so that they do not demand consideration, except when dealing with long lines.

(*a*) "The disturbing influence of differential attraction of the sun and moon on the direction of gravity and its effect on spirit leveling" is discussed by Charles A. Schott, assistant, in Report of the Coast and Geodetic Survey, 1887, page 196, and does not appear to warrant much consideration, though this element may be largely eliminated by dividing the work equally between the two halves of the day.

(*b*) The effect of the spheroidal shape of the earth on long level lines is expressed by the formula $\triangle h=0.832\ A \sin 2\varphi$, in which $\triangle h$ is the correction in millimeters applied to elevation above sea level at the terminus of a line for which φ is the mean latitude and A is the area, in square kilometers, of the area included between the profile of the level line and sea level projected on to the middle meridional plane. For a line running from south toward north this correction would be positive at the north end of the line. As will be seen, this error is zero for an east and west line.

2. The sources of error pertaining to the level tube are as follows:

(*a*) The lack of parallelism of the level tube with the vertical plane through the telescope axis, which can be avoided only by careful adjustment.

(*b*) The horizontality of the level tube, which can be righted by adjustment only to the extent of making the error small. The error still remaining, which is very variable, can be eliminated in the observations only by reading the level in a direct and reversed position.

(*c*) The parallax between the images of the bubble and the level-tube graduation, as seen in the mirror, can be eliminated by adjusting the inclination of the mirror and reading with the eye always in the same position, or a correction for resulting inclination may be applied.

(*d*) The error of pointing or position of the bubble with reference to the center of its graduation. This may be reduced by great care, and it may be practically eliminated by a level tube which is so delicate that the ordinary displacements of, say, 0.2 divisions do not affect the rod readings for the ordinary long sights.

3. The errors resulting from the telescope are as follows:

(*a*) The reticule errors, which should be made small by careful adjustment. The horizontal threads should be horizontal in both normal and inverted positions of the telescope, and the center of the reticule should be made to coincide with the rod image at a certain distance, say 50 meters, for both normal and inverted positions of the telescope. This is the thread adjustment, commonly, but erroneously, called collimation adjustment. The error of horizontality can be eliminated by always reading the threads on the same side of and adjacent to the vertical thread. Any thread error still remaining is eliminated by normal and inverted telescope positions.

(*b*) The mounting of the objective lens causes an error in axial inclination when the optic center of the lens is not on the axis of the telescope, as defined by the centers of the telescope collars. This can not be adjusted, though the error exists to some degree in every instrument. Rod readings for the normal and inverted positions of the telescope will eliminate this error.

(*c*) The direction of motion of the eyepiece slide should be parallel to the telescope axis; otherwise the line of sight changes its inclination for every position of the slide. When there is no lateral looseness in the slide, this may be eliminated by readings in normal and inverted positions of the telescope, when the back and fore sights are nearly enough equal so that both readings can be taken without refocussing.

(*d*) Inequality in the telescope collars produces an axial inclination which is of a very complicated nature and which can not be directly determined. The method given in text-books to determine the collar correction is altogether worthless, owing to the unequal wear of the parts and the unequal penetration of the collars (when of different diameters) into the forked supports of the level tube and the cradle. This inequality may be eliminated by strictly equalizing the sums of back and fore sights for every stretch; otherwise a correction must be applied for excess of foresight.

4. The rod errors are due to erroneous graduation, changes in temperature, and estimation of rod readings. Rods are held so nearly vertical by the aid of watch-glass levels attached to them that there is no error from lack of verticality.

(*a*) The errors of graduation and temperature are corrected by comparisons made, at the beginning and end of each stretch, of the two rods with a carefully standardized steel tape especially kept for this purpose. The actual length of the tape is found from a tabulation of tape errors for each degree of temperature within working limits between 20° and 95° F. The rod temperatures are noted at the beginning and end of each stretch by thermometers set into the wood. The mean length of the four comparisons corrected to the mean temperature is then the accepted rod length for the difference of elevation between two successive benches.

(*b*) The error of estimation can not be entirely eliminated, and varies in amount, depending on the quality and fineness of the thread, the length of shot, and the expertness of the observer. The kind of rod graduation is a most important factor, and has been discussed at some length in describing the instruments. It appears from practice that the desired accuracy of estimation, equal to the attainable accuracy of pointing, etc., can be obtained from a rod graduated to 2 mm.

5. *Atmospheric effects.*—These are occasioned by changes in humidity, density, and temperature of the air, and to some extent by the direction of the sun's rays with respect to the direction of the level line. Hence the time of day and season of the year are important factors in leveling.

(*a*) Air vibrations are caused by the sun in warming up the atmosphere as the day advances, and when the sun has passed the zenith and the air has reached its maximum temperature these vibrations diminish and finally cease, until the air begins to cool and the earth radiates the heat imparted to it by the sun during the day, thus causing a reverse vibration. These vibrations are most severe when the humidity is high and the air is clear, warm, and quiet. They are rapidly diminished by light wind or passing clouds. The effect of vibration must be avoided or reduced by shortening sights and reading back and fore sights in quick succession so as to get both sets of readings for the same conditions. Any change in conditions, as of a passing cloud or a puffy wind, will make errors unavoidable.

(*b*) Direction of line, temperature, and time of day is liable, in warm weather, to cause one of the most serious errors encountered in leveling. The most perplexing feature of this troublesome influence is that it does not make itself apparent until a line has been closed, because the adjustments of the level do not seem to be materially affected, although the line of sight is seriously altered and may cause as much as 3 mm. error in a single shot. To prove the importance of this question, the writer made some experiments by setting up the instrument and placing the rods in fixed positions equidistant from the instrument, which was shaded from the sun by a large umbrella. Regular sets of back and fore sight readings were taken all day, and the difference of elevation found for different hours of the day diminished successively from 9 a. m. until 12 m., after which time the value again increased and became normal about 4.30 p. m. The temperature during the day, Sunday, July 2, 1899, varied from 85° to 96° F., and the maximum error in the difference of elevation at noon was 0.9 mm. for rods placed 35 m. each side of the instrument.

This showed that no reliable levels could be run between 9 a. m. and 4.30 p. m. of that day. It is to be regretted that such experiments could not be extended, but no authority was obtainable for such work. This would suggest the propriety of leveling at night when work is to be done during the warm summer months.

(*c*) The best season of the year in northern climates is certainly the fall, say from September 1 to December 1, and early spring, March, April, and May. No work should be done during other months of the year except with due regard to the difficulties which will be met.

6. Personal errors are those resulting from erroneous rod readings or faulty recording. Rodmen may also introduce errors by carelessness. However, in all the work done by the writer there has never been one failure in closing a line which could be attributed to any of

these causes, which does not mean that the members of the party were infallible, but that the methods adopted were very nearly so, at least to the extent of eliminating personal errors.

The various sources of error having been described, it may be of interest to outline the methods adopted by the writer for their elimination.

4. INSTRUMENT CONSTANTS.

The instrument, level tube, cross threads, and rods are first carefully adjusted, and the following constants of the instrument are then determined on an accurately measured 100 m. base line: The value of the thread interval, the curvature of the level tube per 2 mm. division, the magnifying power of the telescope, and the axial inclination of the telescope resulting from collar inequality. The objective mounting, the eyepiece, and the movements of the latter are carefully examined. The distance A, from the zero of graduation to the end of the rod or point held on, is accurately measured for each rod, and should be made alike in the two rods by filing, or, better, by a facing machine.

It is not necessary here to give the methods of making these determinations, except the effect of collar inequality, which can not be correctly found by the method commonly given in text-books. For this reason the following special method was devised by the writer: The instrument is set up at the middle point, or 50-meter point, of the base line, and ten sets of back and fore sights are taken on the zero and 100 m. points. This gives the true difference of elevation between the end points of the base with all instrumental errors eliminated. The instrument is then set up at some other point, say 15 m. from the zero end, and ten sets of readings taken on the end points of the base as before. This gives a difference of elevation involving an excess of sights of 70 m. from which the axial inclination per meter can be found. This constitutes what has been called the residual correction for excess of sights.

In taking these readings each set is made up of four readings, one pair of back and fore sights with telescope normal and bubble direct, and one pair with telescope inverted and bubble reversed, thus eliminating bubble and collimation error in each set. The height of the instrument is slightly altered between taking sets.

The movements of the eyepiece are tested in a similar manner by occupying other points of the base in the way just outlined and then deducing the line representing the inclination of the line of sight, which should be constant for all sets, otherwise the eyepiece moves irregularly, and such an instrument is practically worthless.

As will be seen, this " residual correction " includes the axial inclination resulting from the combined errors of the collars and the parallax of the mirror, while all errors of the level tube, reticule, eyepiece movements, and mounting of the objective lens are eliminated in the observations by the reversals of telescope and level tube.

5. METHODS.

All level notes are recorded in ink, in notebooks 5 by 7½ inches, after a uniform system, and bench-mark descriptions are entered in regular order in a separate notebook for that purpose. A final summary of results, including the computation of probable errors and final elevations, is compiled in a 9 by 12 inch notebook. The locations of all bench marks, and other useful information are platted on a map of the locality. United States Lake Survey charts were used for this purpose.

Each field book contains a brief statement of methods, programme of reading, definition of instrument positions, names of observer and recorder, instruments used, units of measure, etc., on the front page. The notes following are all entered according to the system defined on front page, and the last double page is devoted to a summary of the results, with page index for work recorded in the book.

The method employed on this work was such as to eliminate all instrumental errors in the observations themselves, obviating as far as possible all mathematical manipulations in the form of corrections, it being considered that good observations lead to the best attainable results.

This was accomplished by the following system of observing: With the telescope normal and level tube direct, the first reading was taken on the rear rod. Then, without disturbing the instrument, except at the micrometer screw, the telescope was swung onto the front rod and reading taken. The level tube was then removed and replaced in a reversed position, meanwhile inverting the telescope. The front rod was then read for the second time, and likewise the rear rod. All readings were taken with the bubble in the center, and back and fore sights were made equal by the rodmen by counting paces. The sights must be so nearly equal that both rods can be read without refocusing; otherwise the front rod must be set correctly and the process of reading be commenced anew.

By this means all instrumental errors are absolutely eliminated, when the sights or sums of sights are exactly equal. When the sums of sights, as determined by the thread distances, are not equal, then the "residual correction" previously described must be applied to the excess of fore sight. This is the only correction necessary, with exception of the correction for rod length and temperature.

As is readily understood from the above, there is no need of measuring the errors of thread adjustment and level tube with this system of observing, and no attempt was made to trace these errors, except that they were kept small by frequent adjustment.

By careful inspection of the recorded readings the recorder can always see at a glance whether there has been an error of reading or recording; and should any disparity exist, or any irregularity from atmospheric influences be noticeable, the readings are repeated until a rational set is obtained. This is the secret to the success of this method. The only disturbing influence which can not be detected in the readings, even though it may be acting, is the warping of the telescope caused by direct and radiated heat in warm weather.

The warping of the telescope is in the same direction during the same half of the day (the direction of the line being constant); hence lines run direct and reversed in the same half of the day will reveal this error when it exists, while lines run direct in the forenoon and reverse in the afternoon (or conversely) may close well and both be badly in error.

For this reason a stretch should always be closed in the same half of the day, and a good closure will then be guaranteed against all injurious temperature effects.

The use of a large sun umbrella is indispensable as a protection against wind, rain, and sunshine, and it rarely ever happens that work could be done without it.

All lines were run direct and reverse, using the method above outlined, and the errors of closure of the loops formed by each pair of lines were limited to the value $e = 3\sqrt{2K}$ for the St. Lawrence River levels, and to $e = 3\sqrt{K}$ for the Lake St. Clair levels. In these formulas e is the error of closure in millimeters and K is the length of the stretch in kilometers.

On direct lines the back sights were considered positive and the fore sights negative, while on reverse lines these signs were reversed, thus giving the same sign to the difference of elevation, whether determined from a direct or reverse line.

Whenever possible the rod was used in reading on permanent bench marks. However, such marks as were made by bolts, cemented horizontally into buildings, etc., did not permit of this, and in these cases the readings were taken on a metallic steel tape at short range. Such readings were always reduced to rod length by direct comparisons, made immediately after taking the readings, and the quantity A (being the distance from the zero of graduation to the end of the rod) was always subtracted from the tape readings to reduce them to equivalent rod readings.

No rod corrections were made in this work, because the necessary comparisons with the standard meter are not yet made, though it is known from past comparisons that the rod errors are practically zero.

It will be seen that the method here outlined eliminates as far as possible all accidental and variable errors, leaving only the "residual error" (a constant) to be applied to any excess of sights that may remain when a stretch is closed. The only other corrections to these differences of elevation are those occasioned by graduation errors and temperature effects on the level rods.

The spheroidal error previously mentioned is of purely theoretical origin and need receive no consideration except for long lines at high altitudes, when the error should be corrected in the final results.

The error of closure is thus generally made up of the error of estimation and atmospheric effects. The former component is generally very small with an experienced observer, and would never produce any serious consequences; but the temperature effects and sudden changes, as from passing clouds, etc., make up the large errors which may often necessitate a repetition of work.

It is needless to look for errors of heaving or settlement of rods or instrument when only ordinary care is exercised and the pins previously described are employed. These errors, if they exist, are far too small to be detected, even with the most sensitive instrument, unless when working on frozen ground, which is always a doubtful operation.

The atmospheric effects are eliminated from the work by closing each stretch in the same half of the day and dividing the work equally between forenoons and afternoons.

A sample of the system of note keeping may be valuable and is given below. All rod readings are in decimeters, likewise all other dimensions except where other units are indicated. The observed rod readings always occupy the first two lines and the means are written on the third line for each sight. Otherwise the notes are self-explanatory. A sample of summary of results for index page of notebooks is also given.

It appears from these notes, the manner in which they are recorded, and the system of observing previously described, that there is scarcely any possibility of an error, due to misreading or erroneous recording, creeping into the work. In fact, no such errors, even though they were occasionally made, ever escaped detection, and hence the personal errors fall into insignificance when this method is employed.

Direct line temporary bench mark 176 to permanent bench mark A., Clayton, May 17, 1899.

BACK-SIGHTS.

Point.	Rod No.	Thread readings.			Mean.	Thread distance.	Temperature.	Remarks.
		(1)	(2)	(3)				
		dcm.	*dcm.*	*dcm.*	*dcm.*	*dcm.*	°C.	
T. B. M. 176	5	11.178 11.176	12.228 12.222	13.276 13.274				
Mean		11.177	12.225	13.275	12.226	2.098	15.5	8.30 a. m., clear, light wind, air vibrating.
T. P. 1	1	15.430 15.434	16.404 16.402	17.388 17.390				
Mean		15.432	16.403	17.389	16.408	1.957		
2	5	10.026 10.026	11.040 11.040	12.058 12.058				
Mean		10.026	11.040	12.058	11.041	2.032		F. S. = −56.932 B. S. = +54.784
3	1	14.508 14.508	15.108 15.110	15.708 15.710				
Mean		14.508	15.109	15.709	15.109	1.201		−2.148 Res. Cor. = −0.0001
Total					54.784	7.288		D = −2.1481

Direct line temporary bench mark 176 to permanent bench mark A., Clayton, May 17, 1899—Continued.

FORE-SIGHT.

Point.	Rod No.	Thread readings. (1)	(2)	(3)	Mean.	Thread distance.	Temperature.	Remarks.
		dcm.	*dcm.*	*dcm.*	*dcm.*	*dcm.*	°*C.*	
T. P. 1	1	10.520 10.516	11.574 11.564	12.610 12.606				
Mean		10.518	11.569	12.608	11.565	2.090		Thread dist.: F. S. = 7.281 B. S. = 7.288 T. D. – 14.569
2	5	15.152 15.154	16.144 16.140	17.128 17.128				
Mean		15.153	16.142	17.128	16.140	1.973		Ex. F. S. = –0.14 m.
3	1	22.166 22.164	23.194 23.192	24.210 24.210				
Mean		22.165	23.193	24.210	23.189	2.045		Tape = rod. 6.524 = 6.524 A = 0.486 6.038
P. B. M. A., Clayton, N. Y.	Steel tape	5.936 5.938	6.524 6.524	7.110 7.110				
Mean		5.937	6.524	7.110	*a*6.038	1.173	16.0	9 a. m., P. B. M. A. on Catholic Church, Clayton, N. Y.
Total					56.932	7.281		

a Mean of steel tape (6.524) reduced to rod measurement.

Reverse line temporary bench mark 176 to permanent bench mark A., Clayton.

BACK-SIGHTS.

Point.	Rod No.	Thread readings. (1)	(2)	(3)	Mean.	Thread distance.	Temperature.	Remarks.
		dcm.	*dcm.*	*dcm.*	*dcm.*	*dcm.*	°*C.*	
P. B. M. A., Clayton.	Steel tape	5.220 5.216	5.810 5.810	6.410 6.406				
Mean		5.216	5.810	6.408	*a* 5.326	1.190	16.[illegible]	9 a. m., clear, light wind, air vibrating.
T. P. 1	1	22.310 22.310	23.280 23.282	24.230 24.230				
Mean		22.310	23.281	24.230	23.274	1.920		Tape = rod. 5.812 A = 0.486 5.326
2	5	15.124 15.122	15.950 15.950	16.776 16.774				
Mean		15.123	15.950	16.775	15.949	1.652		
3	1	11.386 11.386	12.194 12.196	13.002 13.002				
Mean		11.386	12.195	13.002	12.194	1.616		F. S. = –67.599 B. S. = +69.753
4	5	12.570 12.572	13.010 13.008	13.450 13.450				—2.154
Mean		12.571	13.009	13.450	13.010	0.879		Res. cor. = –0.0061 R. = –2.1541
Total					69.753	7.257		Closing error = 0.60 mm.

a Mean of steel tape (5.812) reduced to rod measurement.

Reverse line temporary bench mark 176 to permanent bench mark A., Clayton—Continued.

FORE-SIGHT.

Point.	Rod No.	Thread readings. (1)	Thread readings. (2)	Thread readings. (3)	Mean.	Thread distance.	Temperature.	Remarks.
		dcm.	*dcm.*	*dcm.*	*dcm.*	*dcm.*	°*C.*	
T. P. 1	1	13.802 13.802	14.400 14.400	14.996 14.996				
Mean	....	13.802	14.400	14.996	14.399	1.194	....	
2	5	10.366 10.370	11.334 11.336	12.302 12.304				
Mean	....	10.368	11.335	12.303	11.335	1.935	....	
3	1	14.790 14.788	15.590 15.588	16.390 16.388				
Mean	....	14.789	15.589	16.389	15.589	1.600	....	**Thread dist.:** **F. S. = 7.262** **B. S. = 7.257** **T. D. = 14.519**
4	5	12.664 12.666	13.498 13.500	14.326 14.328				
Mean	....	12.665	13.499	14.327	13.497	1.662	....	**Ex. F. S. = +0.10 m.**
T. B. M. 176	1	12.346 12.344	12.778 12.776	13.218 13.214				
Mean	....	12.345	12.777	13.216	12.779	0.871	16.2	**9.30 a. m.**
Total	....	....	....	....	67.599	7.262		

NOTE.—The ratio of the telemeter threads is 1: 200 and the length of the bubble 70 mm. All readings are taken with the bubble in the center on rods graduated to centimeters.

Sample of index page for field-note books.

SUMMARY OF RESULTS.

B. M. To—	B. M. From—	Number of settings. D.	Number of settings. R.	Mean thread distance.	Mean length stretch.	Excess F. S. D.	Excess F. S. R.	Observed difference of elevation. D.	Observed difference of elevation. R.	Corrected difference of elevation. D.	Corrected difference of elevation. R.
				dcm.	*m.*	*m.*	*m.*	*mm.*	*mm.*	*mm.*	*mm.*
T. 127	T. 126	9	9	52.784	1,066.5	+0.18	+0.46	−2,547.2	−2,547.1	−2,547.19	−2,547.13
128	127	6	7	37.346	754.7	+0.02	+0.20	− 548.3	− 547.3	− 548.30	− 547.31
129	128	8	8	53.083	1,071.3	+0.06	−0.26	+4,397.3	+4,397.3	+4,397.30	+4.397.32
130	129	11	11	70.256	1,418.3	+0.02	+1.90	−2,258.7	−2,258.9	−2,258.70	−2,259.02
P. 34	130	7	7	32.356	655.5	+0.24	−0.02	+1,661.8	+1,663.8	+1,661.82	+1,663.80

B. M. To—	B. M. From—	Actual.	Allow.	Direction of line.	No. of run.	Time of day. Direct. From—	Time of day. Direct. To—	Time of day. Reverse. From—	Time of day. Reverse. To—	M. Temp. D.	M. Temp. R.	Page. D.	Page. R.
		mm.	*mm.*										
T. 127	T. 126	0.06	3.08	N. 80° E.	1	6.15 A.	7.45 A.	4.45 A.	6.15 A.	21.1	17.8	30	29
128	127	0.99	2.59	N. 70° E.	1	7.00 P.	7.45 P.	4.30 A.	5.30 A.	21.1	18.9	33	34
129	128	0.02	3.08	N. 45° E.	1	3.00 P.	5.00 P.	5.30 P.	6.30 P.	23.3	21.7	36	37
130	129	0.32	3.56	E.	1	7.00 P.	7.15 A.	5.00 A.	8.00 A.	20.0	20.0	38	40
P. 34	130	1.98	2.42	E.	1	5.00 P.	6.15 P.	6.15 P.	7.15 P.	23.3	21.1	42	43

NOTE.—The final correction applied to all differences of elevation is +0.063 millimeter per meter excess of foresights for a positive difference of elevation.

On reverse lines the difference of elevation is increased for a negative excess of foresights, taking account, in each case, of the sign of the difference of elevation as given for the direct line.

T = temporary bench mark; P = permanent bench mark and afternoon; A = forenoon; D = direct line, and R = reverse line.

The temperature is recorded in degrees centigrade.

The allowable error $e = 3\sqrt{K}$, where K is the length of the single stretch in kilometers.

6. STATISTICS OF WORK.

The instrument constants were determined whenever the instrument underwent any changes or alterations, and the constants used for the various periods are given in the following table:

Constants.	St. Lawrence levels.		Lake St. Clair, June 4-July 5, 1899.
	Aug. 11-Nov., 1898.	May 1-June 4, 1899.	
Magnifying power of telescope, in diameters	50	50	50
Focal length of objective ... millimeters	402	402	402
Diameter of objective ... do	38	38	38
Ratio of telemeter threads	1:99.532	1:200	1:200
Curvature of level tube, in seconds, per 2 millimeters	5.21	5.00	2.23
Inequality in collars by ordinary method, millimeters per meter	+0.0235	+0.0276	....
Residual error, millimeter per meter, excess of feet-seconds	+0.0635	+0.0630	+0.0630
Weight of instrument ... kilograms	5.3	5.3	5.3
Weight of stand ... do	7.6	7.6	7.6
Smallest graduation on rods ... millimeters	10	10	10
A of rods 1 and 5 ... decameters	0.486	0.486	0.486

The following table gives the statistics of all work done:

Items.	St. Lawrence River.	Lake St. Clair.
Length of main line ... kilometers	197.171	43.62
Number of stretches on main line	242	43
Number of stretches on main line and side lines	285	45
Average length of stretch on main lines ... meters	815.7	1,014.4
Number of instrument settings, entire work	4,430	972
Average length of shot on main line ... meters	49.0	50.4
Length on main line run two times ... kilometers	182.869	34.791
Length on main line run three times ... do	9.791	8.829
Length on main line run four times ... do	3.825	....
Length on main line run five times ... do	0.687	....
Length on side lines run two times ... do	3.715	0.990
Length on side lines run four times ... do	0.290	....
Length on gauge lines run two times ... do	5.559	....
Total single line run ... do	433.552	98.050
Number of permanent bench marks	61	8
Number of temporary bench marks	221	38
Probable error at end of main line ... millimeters	±8.06	±3.2
Probable error per kilometer on main line ... do	±0.57	±0.48
Probable error per kilometer for the last 88 kilometers ... do	±0.48	[a] ±0.33
Actual closure at end of main line ... do	±1.07	±2.04
Residuals passed through zero ... times	14	....
Maximum value of residuals from mean ... millimeters	±14.72	±5.44
Average number of instrument settings per kilometer	10.6	9.9

[a] 41 kilometers.

On the St. Lawrence River levels 6.3 per cent of the lines run did not close on the first pair, and during the last 118 stretches or 88.4 kilometers every line closed on the first pair, though one 600-meter stretch was run a third time because the first pair closed nearly at the limit and had been run during very severe wind, combined with extreme radiation and strong sunlight. This record has never been equaled or even approached by any other observer.

The Lake St. Clair levels were run during the month of June, 1899, and, as has been previously mentioned, the extremely warm weather prevailing at the time caused much trouble, and until the real cause could be ascertained a number of stretches had to be rerun. Thus 8 stretches out of 45 were run a third time, making 17.7 per cent which did not close on the first bout. No stretch was run four times because the erroneous line of the first pair could always be spotted by reviewing the remarks relating to weather and time of day. The first three stretches of this line were run during the warm part of the day and their closures, while decidedly within the limits, are not on a par with the remaining work. Hence the probable error of the 40 stretches or 41 kilometers was separately computed and found to be ±0.33 as against ±0.48 for the 43 stretches. This is the highest accuracy ever attained on precise levels, and it was done during the worst season of the year.

The following table shows the magnitude of the closures for all accepted work:

Closing errors (mm.).	Number of stretches.		Closing errors (mm.).	Number of stretches	
	St. Lawrence River.	Lake St. Clair.		St. Lawrence River.	Lake St. Clair.
0 to 0.5	85	13	2.0 to 2.5	13	5
0.5 to 1.0	54	12	2.5 to 3.0	18	3
1.0 to 1.5	45	3	3.0 to 3.5	17	....
1.5 to 2.0	33	7	4.0 to 4.5	2	....

The rapidity of the work is represented in the following table:

Items.	St. Lawrence River.	Lake St. Clair.
Total number of days in the field	135	27
Number of Sundays	20	5
Number of days lost by rain, etc	9.5	0
Number of days on which work was done	105.5	22
Number of hours actually worked	746	159
Number of kilometers of single line run	433.55	98.05
Number of kilometers single line per day in field	3.21	3.63
Number of kilometers single line per day worked	4.11	4.46
Number of kilometers single line per hour worked	0.58	0.62
Average time consumed per setting, in minutes	10.10	9.81

While the records show an average of about seven hours worked per day, this applies only to the actual field operations, though in reality three or four hours of checking is required each day to keep the notes computed and checked. This work is generally done over the noon hours and in the evening, so that the average working day is from ten to twelve hours long.

7. COST OF WORK.

The cost of St. Lawrence River work was as follows:

Establishing 18 water gauges, distributed over 120 miles	**$131.30**
Reading 18 water gauges at ten-minute intervals for ten days, and superintendence	**438.84**
Materials (cement and brass bolts) for 61 permanent bench marks	**23.79**
Placing 61 permanent bench marks, covering 120 miles	**251.40**
Cost of leveling 433.55 kilometers, single precise level line	**2,354.80**
Final reduction of notes and compilation of results	**360.22**
Traveling expenses for party to and from field	**183.71**
Total	**3,744.06**

Sixty-five dollars of the amount charged to reduction of notes was paid by the United States Lake Survey, the remainder, $3,679.06 was paid by the United States Board of Engineers on Deep Waterways.

The cost of the Lake St. Clair level was as follows:

Cost of leveling 98.05 kilometers, single precise level line and placing benches	**$451.85**
Final reduction of notes and compilation of results	**82.00**
Traveling expenses for party	**13.10**
Total	**546.95**

Paid by the United States Lake Survey.

This gives the following unit prices:

Items.	St. Lawrence River.	Lake St. Clair.
Establishment of permanent bench marks	$4.51	....
Cost of leveling 1 kilometer, single line	5.43	$4.61
Cost of leveling 1 kilometer, direct and reverse	10.86	9.22
Cost of reducing and compiling notes, per kilometer	.83	84

The difference in cost between the St. Lawrence River and the Lake St. Clair levels is due almost entirely to the higher wages paid on the former work and somewhat to the fact that the St. Lawrence River line was very hilly, while the Lake St. Clair line was practically level.

It is difficult to discuss the comparative cost of different levels because so much depends on the character of the work, the ground over which the levels are run, and the liberality in the wages paid.

Generally the inducements are altogether insufficient to warrant following up precise leveling as a speciality, although the subject demands a specialist in the highest sense. The unpleasantness of the occupation is by no means inviting. Working hours are such as necessity demands, and may be any out of the twenty-four. Also, parties are generally subsisted on the farming community, where the conveniences and food are often anything but desirable.

A good man for chief of a precise level party must have little regard for his own welfare and comfort. He must be a hard worker and hustler, willing to labor for a mere existence, and he must be a specialist, possessing a broad scientific training, combined with a faculty for careful and patient research, united with a natural adaptation to artistic manipulations. Few men possessing the required capabilities will seek employment of this kind.

It would not be excessive compensation to increase the rate of pay to the extent of raising the cost of leveling from $9.22 per double kilometer to $13.

A reform, said to have been introduced in France by M. Lellemand in 1884, by which the pay of the party increases in proportion to the square of the number of kilometers run by each party, would be very acceptable here.

The results of the slope observations of the St. Lawrence and St. Clair Rivers are given in the following table, and the elevations and descriptions of bench marks are tabulated in Appendix No. 22:

TABLE NO. 1.—*Slope observations of St. Lawrence River between St. Regis and Cape Vincent, N. Y.*

[Made between July 27 and August 6, 1898.]

No. of gauge.	Location.	Mean gauge reading.	Elevation, zero of gauge.	Mean elevation, surface of water.	Distance between gauges.	Distance from gauge No. 1.	Rise between gauges.	Rise from gauge No. 1.	Slope between gauges.	Slope from gauge No. 1.
		Feet.	*Feet.*	*Feet.*	*Miles.*	*Miles.*	*Feet.*	*Feet.*	*Ft. per mile.*	*Ft. per mile.*
1	Racket River	—1.992	156.587	154.595						
2	Grass River	—2.339	159.183	156.844	3.9	3.9	2.249	2.249	0.577	0.577
3	Robinsons Bay	—2.018	167.697	165.679	3.9	7.8	8.835	11.084	2.265	1.421
4	Pollys Creek	—2.091	175.267	173.176	1.8	9.6	7.497	18.581	4.165	1.935
5	Richards Landing	—2.081	206.873	204.792	5.7	15.3	31.616	50.197	5.547	3.281
6	Louisville Landing	—2.135	208.323	206.188	2.3	17.6	1.396	51.593	0.607	2.931
7	Below Bradfords Hill	—1.946	209.603	207.657	4.1	21.7	1.469	53.062	0.358	2.445
8	Above Bradfords Hill	—1.925	210.908	208.983	0.4	22.1	1.326	54.388	3.315	2.461
9	Murphys Island	—1.878	215.553	213.675	4.7	26.8	4.692	59.080	0.998	2.204
10	Below Waddington Dam	—2.236	217.438	215.202	3.1	29.9	1.527	60.607	0.492	2.027
11	Leshman Point	—2.291	228.703	226.412	2.4	32.3	11.210	71.817	4.671	2.223
12	Point Rockway	—2.136	230.679	228.543	3.4	35.7	2.131	73.948	0.627	2.071
13	Sheldon Island	—2.191	237.996	235.805	4.6	40.3	7.262	81.210	1.579	2.015
14	Butternut Island	—2.261	247.129	244.868	4.3	44.6	9.063	90.273	2.108	2.024
15	Ogdensburg Light-House	—2.344	248.155	245.811	5.8	50.4	0.943	91.216	0.162	1.810
16	Foot of Brocks Group	—2.096	247.966	245.870	12.2	62.6	0.059	91.275	0.005	1.460
17	Alexandria Bay	2.081	248.279	246.198	20.1	82.7	0.328	91.603	0.016	1.108
18	Cape Vincent	—2.318	248.803	246.485	25.5	108.2	0.287	91.890	0.011	0.849

NOTE.—The distances in above table are measured along the river, not along the precise level line.

Table No. 2.—*Slope observations on Lake St. Clair between Windmill Point and New Baltimore.*

[Made July 19, 1899.]

No. of gauge.	Location.	Mean gauge reading.	Elevation, zero of gauge.	Elevation, surface of water.		Distance between gauges.	Distance from gauge No. 10.	Fall between gauges.	Fall from gauge No. 10.	Slope between gauges.	Slope from gauge No. 10.
				Mean.	At noon.						
		Feet.	*Feet.*	*Feet.*	*Feet.*	*Miles*	*Miles*	*Feet.*	*Feet*	*Ft. per mile.*	*Ft. per mile.*
10	New Baltimore, at dock	+3.887	571.736	575.623	575.636	......	......	......	......	....	....
A	Clinton River, 5 miles above its mouth	−0.916	576.567	575.651	575.617	7.1	7.1	0.019	0.019	0.00268	0.00268
B	L'Anse Creuse Bay, at Catholic Church	−0.841	576.462	575.621	575.587	7.0	14.1	0.030	0.049	0.00429	0.00347
C	Milk River Point	−0.964	576.525	575.561	575.525	3.2	17.3	0.062	0.111	0.01938	0.00642
D	Grossepoint, on Newberry Dock	+0.055	575.448	575.503	575.478	4.6	21.9	0.047	0.158	0.01022	0.00717
E	1½ miles above Windmill Point Light-House	−0.910	576.367	575.457	575.417	2.0	23.9	0.061	0.219	0.03050	0.00916
11	Windmill Point Light-House Dock	+0.087	575.222	575.309	575.292	1.1	25.0	0.125	0.344	0.11364	0.01376

Note.—The gauges were read every 15 minutes between 9 a. m. and 6 p. m. on July 19, 1899. The wind was fresh from the east and northeast. At 12 m. the wind abated for a short time and hence the 12 o'clock readings were used for the slope determinations. The distances are over the air lines between the gauges.

I am, very respectfully, your obedient servant,

David Molitor,
Assistant Engineer.

The Board of Engineers on Deep Waterways.

Appendix No. 21.

PRECISE LEVELS ALONG DETROIT AND ST. CLAIR RIVERS.

Detroit, Mich., *February 27, 1899.*

Gentlemen: I have the honor to make the following report upon precise levels between Lake Erie and Lake Huron.

The party was engaged and reported for duty in Trenton, Mich., on September 21, 1898. It consisted of 1 observer, 1 recorder, 2 rodmen, 1 umbrellaman, and 1 axman.

The Kern precise leveling instrument No. 5 with rods Nos. 14 and 17 were borrowed of the Mississippi River Commission for this work. The further equipment of the party was furnished from the Lake Survey Office, Lieut. Col. G. J. Lydecker, Corps of Engineers, in charge, by Mr. E. E. Haskell, assistant engineer. The "turning point" or "rod supports" were specially-designed pins turned from one piece of tool steel.

A former line of levels over this reach, run in 1877, followed the line of the railroads, and so was generally several miles from the waters of the Detroit River, Lake St. Clair, and the St. Clair River. The line discussed in this report followed the highway, generally close to the water, connecting at the start and finish and every few miles with gauges that were read every ten minutes from 7 o'clock a. m. to 6 o'clock p. m. from October 10 to October 15, both inclusive. The readings of the 12th and 14th, on the upper reach, were rejected on account of wind.[1]

This work is divided into two parts:

First, Lake Erie gauge and "U. S. B. M. Gibraltar, 1877," to gauge at the foot of Lake St. Clair, connecting also with bench marks of 1877 at Trenton and Wyandotte; and of 1871 at the Detroit Light-House Depot and with gauges at Wyandotte, "Tecumseh Salt Works," and foot of Eighteenth street, Detroit.

Second, from Lake Huron gauge and "U. S. B. M. Fort Gratiot, 1877," to New Baltimore gauge on Lake St. Clair, connecting also with gauges at Fort Gratiot, Port Huron, Hamilton Place, Marysville, St. Clair, Marine City, and Algonac. Thus leaving a stretch of water levels of 25 miles, from New Baltimore to Windmill Point.[2]

At Trenton the instrument, level tube, and rods were tested and put in good order and observations taken for the instrumental values and the necessary tables made for reducing notes as the work progressed.

Field work was begun on September 24. The party was quartered in the villages and cities along the route.

METHODS OF WORK.

These were similar to those described in Report of Chief of Engineers, 1896, page 1951. Every day, upon starting work, the errors of the instrument were made very small. As the work progressed the sums of backsights and foresights were kept running equal, and at the end of each run, usually closed between 0.0 and 2 meters. At the end of the day's work the errors of the instrument were measured and their algebraic sum, made out in millimeters per meter, applied to the amount of excess for each run.

All lines run forward to the farther or additional point were described as direct lines "D," the other line of each pair, in all cases run in the opposite direction, were described as reverse lines "R."

As an additional caution against large errors, the decimeter figures for each of the three wires were called out first, before the accurate and fine level readings were taken and again repeated afterwards with the whole reading.

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[1] A similar set of gauge readings were made June 26 to July 1, 1899.

[2] Connection between New Baltimore and Windmill Point bench marks was made in 1899 by line of precise levels, the results of which are used in determining the fall between Lake Huron and Lake Erie.

The method of taking but one reading for backsight and one reading for foresight with telescope normal and level direct was followed as usual, and this gives as good results as the method pursued by some precise levelers of taking in additional readings with telescope inverted and level reversed, though the latter will require about one-half as much more time.

The elevations of "base of rail" were taken whenever our line crossed a railroad track.

FIELD COMPUTATION.

If the two lines, between any two bench marks, checked within the prescribed limit, 3 mm. $\sqrt{\text{distance between bench marks in kilometers}}$, it was passed as sufficiently good; otherwise it was rerun, twice as before. This limit is more severe than that heretofore used, which was 3 mm. $\sqrt{2 \times \text{distance between bench marks in kilometers}}$. Thus 3 mm. $\sqrt{\text{K.}}$ for a stretch of 1,000 m. = 3 mm.; former limit gives 4.24 mm.

And 3 mm. $\sqrt{\text{K.}}$ for a stretch of 2,000 m. = 4.24; former limit gives 6 mm.

In making the field reduction the sum of the three wire readings were made at the foot of each page, divided by 3 and made to check with the sums of means for each page. After completing the two runs over a stretch, a field computation was made before leaving the vicinity.

FIELD TABULATION.

A field tabulation giving all necessary information in reference to each stretch was kept along with the field work. This is indispensable as a record to refer to and to compare the office reduction with.

PLOT OF DISCREPANCIES.

A plot of discrepancies between the continuous direct and reverse lines was made; the distance between these lines at any bench mark shows the algebraic summation of the errors of closure at this point from the initial point. If the results are being affected by a "constant" error, its presence will soon be shown by this graphic representation, and, by understanding the principles of the work and the instruments, the observer can soon locate its cause and remove it.

During this season's work our results were affected slightly from a constant error caused for a time by frozen ground, where the pins showed heaving, but this was soon obviated, first by cutting through the frost and later by using stakes.

BENCH MARKS.

Over this line of work are distributed 7 old bench marks, 13 gauges, 16 gauge bench marks, 34 permanent bench marks, 93 temporary bench marks.

Sketches were made of the location of all permanent bench marks, which were established upon masonry structures and lettered when possible "U. S. P. B. M." All bench marks are well described.

Table showing the amount of line and number of times each portion was run.

Times run.	Distance.		Decimal of the whole.	Single line run.
	Meters.	Miles.		
				Miles.
Run twice	118,330	73.542	0.8954	147.084
Run three times	2,923	1.816	0.0221	5.448
Run four times	10,902	6.778	0.0825	27.104
Total	132,155	82.134	1.0000	179.636

Main line completed = 71.838 miles.
Side line completed = 10.296 miles.

RATE OF PROGRESS.

From the time that field work began, September 24, to close of field work, December 15, both inclusive, was 83 days.

Deducting 12 Sundays, on which no work was done, = 71 week days.

Average length of line completed for each of the 71 week days, = 1.157 miles.

Average length of single line run for each of the 71 week days, = 2.530 miles.

Upon completing the line, observations were again taken for instrumental values.

The party was then ordered to the office and disbanded and the property accounted for and placed. Mr. C. Frederic Heyerman, recorder, was retained to assist me in making the office computations.

All of the members of the party were faithful in the performance of their work.

OFFICE REDUCTION.

The 15 notebooks were indexed and labeled.

All observations for instrumental factors were recomputed, and from the corresponding or mean values the necessary tables were made out for use in this final reduction. These are enumerated in Report of Chief of Engineers for 1896, page 1955.

The checking of the field notes was made complete.

A recomputation of all corrections due to collimation and inclination were made, based upon the above values. These corrections aggregate but a small quantity.

A recomputation of difference of elevation from bench mark to bench mark of all runs was made and compared with the field computation point by point.

The results were then compiled on a new tabulation and the chain of results carried through and compared point by point with the field tabulation.

No "rod correction" was applied, owing to the fact that former comparisons of these rods with standard lengths show that they are practically standard, also because the difference of elevations are small.

Office reduction of precise levels, Lake Erie to Lake St. Clair and Lake Huron to Lake St. Clair, September 24 to December 15, 1898.

[Value (n) in seconds of one division of level tube No. 2 used.]

$$\left.\begin{array}{ll}\text{At beginning} & n=1.899\text{ seconds.}\\ \text{At end} & n=1.792\text{ seconds.}\end{array}\right\}\text{Mean value}=1.845\text{ seconds.}$$

$$\left.\begin{array}{l}\text{Tang. of 1.899 seconds}=0.0000092066\text{1.}\\ \text{Tang. of 1.792 seconds}=0.0000086876\text{2.}\end{array}\right\}\text{Mean}=0.0000089471\text{1.}$$

WIRE INTERVALS.

	At beginning of season.	At end of season.
	′ ″	′ ″
Value of lower interval	8 18.56	8 22.78
Value of upper interval	7 42.97	7 48.77
Total	16 01.53	16 11.55
Divergence per meter beyond "(c+f)"	4.7008 mm.	4.7018 mm.

Inequality of telescope rings.—p=The correction to apply to the excessive sights, given in millimeters per meter.

$$\left.\begin{array}{l}\text{At beginning of season } p=-0.00378\text{, eye ring larger.}\\ \text{At end of season } p=+0.00122\text{, object ring larger.}\end{array}\right\}\begin{array}{l}\text{Mean, } p=-0.001.\\ \text{Eye ring larger.}\end{array}$$

"A" of Rods XIV and XVII.—The "A" of a rod is the amount to apply to any reading to give the length from this point (or intercept) to the point the rod is held upon. Made equal by filing.

Mean of 8 measurements gave A=−56.2 mm.

"Br" of Rod XIV.—The "B" of a rod is the distance along the axis of the rod from its square shoulder to the bottom of its spur. Br is this quantity for the right side.

Mean of 3 sets of observations gave Br Rod XIV=−15.6 mm.

Table to find the correction for "inclination" of level tube in millimeters per meter, by taking out the quantity corresponding to the difference of differences of end readings of bubble—"level direct"—"level reverse."

Difference of bubble readings.	Correction in millimeters per meter.	Difference of bubble readings.	Correction in millimeters per meter.
±0.1	± .000224	±0.6	±0.001341
0.2	0.000447	0.7	0.001564
0.3	0.000671	0.8	0.001788
0.4	0.000894	0.9	0.002012
0.5	0.001118		

Also used to correct any rod reading with eccentric bubble to central bubble, by taking out the quantity corresponding to the difference of end readings of bubble and multiplying by 2 and by the number of meters in the sight.

Recapitulation of instrumental factors.

[Office reduction of precise levels, Lake Huron to Lake Erie, September 24 to December 15, 1898.]

Kern precise level No. 5.	Sept. 24 to Oct. 21.	Oct. 22 to Nov. 18.	Nov. 19 to Dec. 15.
Curvature in one division of level tube No. 2="n"	1.899 sec	1.845 sec	1.792 seconds.
"p" per m. (correction due to inequality of tel. rings)	−0.004	−0.001	+0.001.
"S"=distance at which one division subtends 1 mm	108 m.	112 m.	115 m.
Angular value of intervals:			
Lower	8 min. 18.56 sec.		8 min. 22.78 sec.
Upper	7 min. 42.97 sec.		7 min. 48.77 sec.
Total	16 min. 01.53 sec.		16 min. 11.55 sec.
Divergence per m. beyond (c+f), (c+f)=0.55 m.	4.7008 mm	4.713 mm.	4.718 mm.
"A" of Kern Rods XIV and XVII	−56.2 mm	−56.2 mm	−56.2 mm.
Br of Rod XIV	−15.6 mm	−15.6 mm	−15.6 mm.
Displacement of bubble, one division for 1 m=	0.00920 mm	0.00896 mm	0.00872 mm.
Mean standard of value of 1 m. on rods used	1.000000	1.000000	1.000000.

The standard length of 1 m. on Rods XIV and XVII, respectively, have been determined as follows:

Rod.	Date.	Reference.	Standard length of 1 m.
XIV	Aug. —, 1882	Report Chief of Engineers, 1884, p. 2464	1.000010
XVII	do	do	1.000044
XIV	Sept. 30, 1891	Report Chief of Engineers, 1892, p. 3076	0.999948
XVII	do	do	1.000028
		Mean of all	1.000007

DEGREE OF PRECISION ATTAINED.

In this line of work there were 345 lines run from one bench mark to another.

Of these, 11 pairs were rerun because they did not check within the limit.

The largest of these discrepancies was one of 6.7 mm.; 3, in all, were greater than 5 mm.; and 4 were between 4 and 5 mm. Thus the greatest discrepancy in any two lines during the whole season's work was 6.7 mm. = 0.022 foot, and the length of this stretch was 1,436 meters = 0.9 miles; that is, the distance in which this 0.022 foot was accumulated was 1.8 miles, the length of the loop. It might be added that this error was plainly attributable to the action of frost.

For this line, the probable error per kilometer is 0.48 mm.

A probable error of ±0.48 mm. per kilometer gives a probable error of 6.1 mm. for a line 100 miles long.

The descriptions and elevations of the permanent bench marks established during the progress of this work are given in Part III, Appendix No. 22.

The plane of reference of the elevations given is mean tide at New York, as given in Professional Papers, Corps of Engineers, United States Army, No. 24, page 616.

Very respectfully submitted.

O. W. FERGUSON,
Assistant Engineer.

The BOARD OF ENGINEERS ON DEEP WATERWAYS.

APPENDIX NO. 22.

DESCRIPTION AND ELEVATION OF BENCH MARKS.

These bench marks were established during the progress of the surveys for deep waterways. The list is divided into three parts, corresponding to the three initial bench marks. All elevations are given in feet and decimals above mean tide at New York and depend on the adopted elevation of the initial bench of the part in which the elevation appears.

Part I.—The initial bench mark of Part I is the Greenbush bench mark, and the adopted elevation 14.73. The lines of levels here included are fully reported on in Part III of the report of Charles L. Harrison, principal assistant engineer, Appendix No. 10.

Part II.—The initial bench mark of Part II is the one on the lighthouse at Buffalo, whose elevation was established by the United States engineers as 589.807 above mean tide at New York. This elevation was adopted as a starting point for all levels run under the direction of Mr. Charles L. Harrison, assistant engineer in charge of Niagara Ship Canal surveys.

These levels were run with a Buff & Berger wye level. All lines were run twice, the second run being in the opposite direction from that of the first, and the mean of the two runs used in establishing elevations. The work was commenced in September, 1897, and completed in February, 1898. The main line extends from Buffalo to Olcott via Tonawanda, with three side lines, as follows:

A line crossing the Niagara River on the International Bridge at Buffalo, and thence extending south along the river to Lake Erie. A line along the River Road from North Tonawanda to Niagara Falls. A line near the Military Road from Lasalle to Lewiston.

Part III.—The initial bench mark of Part III is the United States Lake Survey bench mark Gibraltar (1877), at Gibraltar, Mich. The Lake Survey established its elevation at 582.45 above mean tide at New York, and this elevation was adopted by the Deep Waterway

Survey. Two lines of precise levels were run by Assistant Engineer Ferguson in 1898; the one from the bench mark at Gibraltar to Grosse Point, at the foot of Lake St. Clair, and the other from the United States Lake Survey bench mark, Fort Gratiot, at the foot of Lake Huron, to New Baltimore, on Lake St. Clair. These lines are described in Mr. Ferguson's report, Appendix No. 21.

In 1899 Mr. David Molitor joined Mr. Ferguson's lines by a line of precise levels along the shores of Lake St. Clair. The elevations given in the lists (Part III) all depend on the Gibraltar bench mark, the elevations established by Mr. Ferguson from New Baltimore to Lake Huron having been changed in accordance with Mr. Molitor's line.

PART I.

BENCH MARKS ON EAST SIDE OF HUDSON RIVER, BETWEEN HUDSON AND GREENBUSH, N. Y.

[The distances recorded in these tables are measured along the line on which the levels were run.]

Description of location.	Distance from United States Coast Survey bench mark at Greenbush, N. Y., in miles.	Elevation above bench mark at Greenbush, N. Y.	Elevation above mean tide at New York.
At Hudson City, N. Y. A knob in square on top stone at northwest corner of south abutment of bridge No. 298, N. Y. C. and H. R. R. R., about 3,200 feet south of Hudson City R. R. Station.	28.20	−6.94	+ 7.79
At Hudson City, N. Y. A round-headed bolt in west side of top of stone pier under iron column of overhead bridge on street leading to the docks and Athens ferry. The pier is the second from the south in the first row of columns from the east.	27.60	- 3.50	+11.23
Near Hudson City, N. Y. Center of square cut in top stone at northeast corner of north wing wall of bridge No. 313 of N. Y. C. and H. R. R. R. about 5,500 feet north of Hudson City R. R. Station.	26.50	−6.14	+ 8.59
At Stockport Station, N. Y. Center of square cut on northwest corner of south abutment of bridge No. 307, N. Y. C. and H. R. R. R., just south of Stockport Station.	23.55	−7.45	+ 7.28
At Stockport Landing Center square cut in large stone on east side of N. Y. C. and H. R. R. R., 10 feet from east rail and 1,000 feet south of Stockport boat landing.	22.75	−3.77	+10.96
Near Stockport Landing, N. Y. A square cut in top stone at northwest corner of bridge No. 311, N. Y. C. and H. R. R. R., about 4,200 feet north of Stockport Landing.	21.70	−5.66	9.07
Near Coxsackie Station, N. Y. A cross in circle on stone on southeast wing wall of bridge No. 318, N. Y. C. and H. R. R. R., about 2,800 feet north of Coxsackie Station.	19.65	−7.30	7.43
At Stuyvesant, N. Y. A cross in circle on southwest corner of sill of door to waiting room on west side of Stuyvesant Station building.	17.80	− .68	14.05
Between Stuyvesant and Castleton, N. Y. Center of square cut in stone on southeast corner of stone culvert on N. Y. C. and H. R. R. R., about 1,300 feet south of road to Stuyvesant light-house.	16.40	−7.28	7.45
Between Stuyvesant and Castleton, N. Y. A cross in circle on bolt on north davit for boat at Stuyvesant light-house and 3 feet north of northwest corner of light-house.	16.15	−4.91	9.82
Between Stuyvesant and Castleton, N. Y. Center of square cut in top stone on the southwest corner of bridge No. 326, N. Y. C. and H. R. R. R., about 2,600 feet south of south end of Hotaling Island.	15.20	−5.30	9.43

PART I—Continued.

BENCH MARKS ON EAST SIDE OF HUDSON RIVER, BETWEEN HUDSON AND GREENBUSH, N. Y.—Continued.

Description of location.	Distance from United States Coast Survey bench mark at Greenbush, N. Y., in miles.	Elevation above bench mark at Greenbush, N. Y.	Elevation above mean tide at New York.
Between Stuyvesant and Castleton, N. Y., opposite New Baltimore light-house Center of square cut on natural ledge, 60 feet east of N. Y. C. and H. R. R. R. track, in line with south side of warehouse at dock for loading brick, 1½ miles south of Schodack Landing.	13.20	−2.89	11.84
Near Castleton, N. Y A cross on stone on east side of foundation of water tank, near signal tower No. 94 on N. Y. C. and H. R. R. R. and opposite Mulls light-house.	10.25	+ .69	15.42
Near Castleton, N. Y A square cut on stone on east end of culvert No. 337 of N. Y. C. and H. R. R. R., about 2,200 feet south of Castleton light-house.	9.16	−3.73	11.00
Near Castleton, N. Y A cross in circle cut on stone forming second step of southwest wing wall of bridge No. 339 of N. Y. C. and H. R. R. R., about 1 mile south of Castleton, N. Y., and opposite Castleton light-house.	8.71	−1.69	13.04
At Castleton, N. Y A cross cut in stone sill of north door on west side of N. Y. C. and H. R. R. R. depot at Castleton, N. Y.	7.75	+3.07	17.80
Near Castleton, N. Y A square cut in stone at southwest corner of north abutment of bridge No. 341 of N. Y. C. and H. R. R. R., opposite lower end of Campbells Island and about 1 mile north of Castleton Station.	6.80	−1.07	13.66
At Greenbush, N. Y A cross cut on the northwest side of the northeast corner of stone foundation of old grist-mill near the river at the foot of and on the south side of Second avenue, established by the United States Coast and Geodetic Survey in 1857, and is known as the Greenbush Bench Mark.	....	....	14.73

BENCH MARKS ON THE EAST SIDE OF THE HUDSON RIVER, BETWEEN GREENBUSH AND TROY, N. Y.

At Greenbush, N. Y See description above.	....	....	14.73
At Rensselaer, N. Y A cross cut in stone on southwest corner of foundation of water tank at the south end of viaduct on which Broadway, Rensselaer, crosses the N. Y. C. and H. R. R. R.	1.38	+7.48	22.21
Near Bath-on-the-Hudson Center of square cut in top stone at the northeast corner of stone culvert under the N. Y. C. and H. R. R. R., about 1,000 feet north of Bath Dyke Light.	2.69	+6.59	21.32
Near Troy, N. Y A cross cut in top stone of northwest corner of culvert under the N. Y. C. and H. R. R. R., about 300 feet north of Covills Folly Light.	3.98	+4.42	19.15
At Troy, N. Y A cross cut in the north end of stone doorsill at the south end of the east side of the Trojan Warehouse of the Fuller & Warren Co., on the northwest corner of Monroe and River streets, Troy, N. Y.	6.10	+9.96	24.69
At West Troy, N. Y A cross marked "B. M." on second stone of second course on northeast corner of west abutment of Congress Street Bridge at West Troy, N. Y.	7.06	+7.36	22.09

PART I—Continued.

BENCH MARKS ESTABLISHED IN THE MOHAWK VALLEY, WOOD CREEK VALLEY, ON THE NORTH SIDE OF LAKE ONEIDA, AND ALONG THE ONEIDA AND OSWEGO RIVERS BETWEEN TROY AND OSWEGO, N. Y.

Description of location.	Distance from United States Coast Survey bench mark at Greenbush, N. Y., in miles.	Elevation above bench mark at Greenbush, N. Y.	Elevation above mean tide at New York.
At West Troy, N. Y A cross, marked "B. M.," on second stone of second course on northeast corner of west abutment of Congress Street Bridge, at West Troy, N. Y.	7.06	7.36	22.09
At Waterford, N. Y A crow foot on the southwest corner of bridge seat on the north abutment of the Delaware and Hudson R. R. bridge over the Fourth Branch of the Mohawk River.	12.07	15.89	30.62
At Cohoes, N. Y Top of coping on southwest corner of east wall of west lock No. 15 of the Erie Canal. This bench mark corresponds to United States Lake Survey bench mark No. 8a: elevation, 160.49.	10.76	146.00	160.73
At Cohoes, N. Y A square cut on south corner of doorsill of house at No. 1 Mohawk street, Cohoes, N. Y.	10.68	97.26	111.99
At Cohoes, N. Y A crow foot on the northeast corner of coping on retaining wall on the east bank of the hydraulic canal and on the west end of Cohoes Falls.	11.48	141.97	156.70
Near Cohoes, N. Y A square cut on the southwest corner of top stone on the south end of breakwater above the Cohoes Water Co.'s gatehouse and near the western end of this company's dam.	12.09	146.91	161.64
Near Cohoes, N. Y The highest point, marked "B. M.," of corner stone on the southeast face of the southeast corner of the south wing of the east abutment of bridge over the Erie Canal about 5,600 feet south of the southern end of the Lower Mohawk aqueduct. This bench mark corresponds to the United States Lake Survey bench mark No. 9a, elevation 193.92.	12.93	179.48	194.21
Near Crescent, N. Y A cross in circle cut in south corner of coping stone on south wing of northeast abutment of second bridge over the Erie Canal south of the Lower Mohawk aqueduct, and about 3,200 feet south of the southern end of this aqueduct.	13.44	178.54	193.27
At Crescent, N. Y A cross cut in circle on top of coping on the southwest corner of the southwest wing of the Lower Mohawk aqueduct, and corresponds to the New York State survey bench mark No. 59.	14.05	180.82	195.55
At Dunsbach Ferry, N. Y On the southeast corner of bottom stone of doorstep on south side of house, about 200 feet south of south end of bridge over the Mohawk River.	16.49	172.32	187.05
At Niskayuna, N. Y A cross cut on corner of top stone of foundation on the southwest corner of the depot of Troy and Schenectady Branch of N. Y. C. and H. R. R. R. at Niskayuna.	21.40	182.33	197.06
Near Vischers Ferry, N. Y On north corner of north stone of northeast end of culvert No. 37, on Troy and Schenectady Branch of N. Y. C. and H. R. R. R., about 1 mile west of Vischers Ferry.	23.52	185.66	200.39
Near Aqueduct Station, N. Y A cross cut in southeast corner of capstone of culvert No. 40 on the Troy and Schenectady Branch of the N. Y. C. and H. R. R. R., about 6,000 feet east of railroad station.	26.23	257.98	272.71
At Aqueduct Station, N. Y A square cut in extreme west corner of step under ladies' entrance to the railroad station of the Troy and Schenectady Branch of the N. Y. C. and H. R. R. R.	27.41	256.54	271.27
Near Aqueduct Station, N. Y The extreme southeast corner of top of keystone of bridge No. 44 of the Troy and Schenectady Branch of the N. Y. C. and H. R. R. R., about 3,000 feet west of railroad station.	28.01	250.17	264.90

PART I—Continued.

BENCH MARKS ESTABLISHED IN THE MOHAWK VALLEY, ETC.—Continued.

Description of location.	Distance from United States Coast Survey bench mark at Greenbush, N. Y., in miles.	Elevation above bench mark at Greenbush, N. Y.	Elevation above mean tide at New York.
At Schenectady, N. Y A square cut on the southwest end of the top of the south west coping stone of culvert No. 47 of the Troy and Schenectady Branch of the N. Y. C. and H. R. R. R., opposite the Schenectady Locomotive Works and about 400 feet east of Romeyn street crossing.	30.70	226.34	241.07
At Schenectady, N. Y A cross cut on the southeast corner of foundation stone of the northwest column of the Church Street Bridge over the Erie Canal.	31.53	218.94	233.67
Near Schenectady, N. Y On northwest corner of top of north stone in third course of the east abutment of bridge No. 63 over Erie Canal, about 1¼ miles west of Rotterdam Street Bridge at Schenectady.	33.41	221.00	235.73
Between Schenectady and Rotterdam Junction, N. Y A square cut on the east corner of the northwest end of the southwest wall of northeast lock of lock No. 24 of the Erie Canal, about 3,000 feet west of the Schenectady waterworks.	34.77	228.54	243.27
Between Schenectady and Rotterdam Junction, N. Y A square cut on the north corner of the bottom stone step at the east corner of brick house, about 700 feet east of the Erie Canal aqueduct, which is about 2 miles east of Rotterdam Junction, N. Y.	36.00	236.64	251.37
At Rotterdam Junction, N. Y An arrow cut on the north corner of projecting course of brick on the north corner of brick house, about 700 feet east of lock No. 25 of the Erie Canal, and about 150 feet south of the schoolhouse.	38.61	237.81	252.54
Between Rotterdam Junction and Pattersonville, N. Y A square cut in the coping stone west of the center and on the north edge of coping on the north end of culvert under highway, about 1,600 feet east of railroad bridge over the Mohawk River, which is about 1 mile east of Pattersonville, N. Y.	39.77	233.11	247.84
At Pattersonville, N. Y A square cut on northeast corner of large square stone under foot of flight of steps on southwest corner of coal shed, opposite Pattersonville Hotel, and about 300 feet east of West Shore R. R. station.	41.00	257.53	272.26
Near Cranesville, N. Y Top of east corner, marked "B. M.," of south wall of north lock of lock No. 26 of Erie Canal. This corresponds to bench mark No. 21 of the United States Lake Survey, elevation 264.23.	44.86	249.63	264.36
Near Amsterdam, N. Y A square cut on the northeast corner of the west abutment of bridge No. 238 of the West Shore R. R., about 9,000 feet east of bridge over the Mohawk River at Amsterdam, N. Y.	46.11	266.56	281.29
At Amsterdam, N. Y A square cut in the top of the north corner of the northwest abutment of bridge No. 242 of the West Shore R. R., crossing Chuctenunda Creek at Amsterdam, N. Y.	48.06	264.98	279.71
Near Akin, N. Y A cross cut in top of iron bolt in coping on east wall between the two locks of lock No. 28 of the Erie Canal. This corresponds to bench mark No. 24a of the United States Lake Survey, elevation 280.43.	50.45	265.86	280.59
Near Fort Hunter, N. Y A square cut on the east corner of the coping on the southwest end of the northwest abutment of first bridge over the Erie Canal east of lock No. 29, and about 1 mile east of Fort Hunter.	52.19	268.46	283.19
At Fort Hunter, N. Y A square, marked "B. M.," cut on lower course of the extreme southwest corner of the northwest side of the Erie Canal aqueduct over Schoharie Creek.	53.27	284.95	299.68
Near Auriesville, N. Y A square cut on the west end of west wing wall of north abutment of bridge over the Erie Canal, about 2,000 feet west of West Shore R. R. station at Auriesville.	54.97	288.79	303.52

Part I—Continued.

BENCH MARKS ESTABLISHED IN THE MOHAWK VALLEY, ETC.—Continued.

Description of location.	Distance from United States Coast Survey bench mark at Greenbush, N. Y., in miles.	Elevation above bench mark at Greenbush, N. Y.	Elevation above mean tide at New York.
Near Fultonville, N. Y A point cut on the face of the most westerly stone, about 3 feet from the corner, of the first course of the west wing wall of the north abutment of bridge over the Erie Canal. The bridge is the third east of the Main Street Bridge at Fultonville, and is about 7,000 feet from this bridge.	56.88	284.49	299.22
At Fultonville, N. Y A square cut on the top of projection on the face of the fourth stone of the second course on the west end of the north abutment of the first bridge over the Erie Canal west of the Main Street Bridge at Fultonville, N. Y.	58.28	285.97	300.70
Between Fultonville and Yatesville, N. Y A projecting point on the upper west corner on the face of the second stone from the west corner of the west wing wall of the north abutment of the first bridge crossing the Erie Canal east of the Erie Canal aqueduct, about 3 miles west of Fultonville, N. Y.	60.72	285.40	300.13
Near Downing Station, N. Y The top of small projection on the first course of masonry, at the angle of the east wing wall with the face of the north abutment, on the first bridge over the Erie Canal east of Downing Station, N. Y.	62.28	285.82	300.55
Near Downing Station, N. Y A square cut on the southwest corner of coping on Erie Canal aqueduct, about 3,300 feet west of station of West Shore R. R. at Downing, N. Y.	63.68	283.32	298.05
Between Downing and Sprakers, N. Y A square cut on the northeast part of the northwest wing of the north wall of the second Erie Canal aqueduct, west of Downing Station, N. Y., and about 2 miles from this station.	64.78	283.31	298.04
Near Sprakers, N. Y A point on the face of the second stone from the east end in the first course of the east wing of the north abutment of the first bridge over the Erie Canal east of lock No. 31 at Sprakers, N. Y.	66.56	284.95	299.68
Near Sprakers, N. Y A square cut on the middle of the face of the first stone from the east end in the first course of the east wing of the north abutment of the third bridge over the Erie Canal west of the Erie Canal aqueduct at Sprakers, N. Y., and about 1 mile from this aqueduct.	67.96	289.61	304.34
At Canajoharie, N. Y A cross cut on the corner of stone at the east corner of the second course of stones from the top on the south face of the stone foundation of the old barn near the upper footbridge across the Erie Canal at Canajoharie, N. Y. This corresponds to bench mark No. 31 of the United States Lake Survey, elevation 307.01.	70.50	292.53	307.26
Near Fort Plain, N. Y A point dressed square on the top of the east corner of the second course of masonry of the southeast wing of the northeast abutment of the first bridge over the Erie Canal east of the steel skew bridge of the West Shore R. R. at Fort Plain, N. Y.	72.86	293.45	308.18
At Fort Plain, N. Y On the extreme south corner of the southeast capstone at the end of southeast wing of the northeast abutment of the first bridge over the Erie Canal west of the River Street Bridge at Fort Plain, N. Y.	74.00	300.06	314.79
Near St. Johnsville, N. Y A square cut on the south corner of the capstone of the southeast wing wall of the northeast abutment of the first bridge over the Erie Canal east of lock No. 33, and about 1¼ miles east of St. Johnsville.	77.46	299.10	313.83
Near St. Johnsville, N. Y A point in hollow of face of the second stone in the second course of the east wing of the north abutment of the first bridge over the Erie Canal east of the St. Johnsville station of the West Shore R. R. This corresponds with bench mark No. 34 of the United States Lake Survey, elevation 320.	78.66	305.52	320.25

PART I—Continued.

BENCH MARKS ESTABLISHED IN THE MOHAWK VALLEY, ETC.—Continued.

Description of location.	Distance from United States Coast Survey bench mark at Greenbush, N. Y., in miles.	Elevation above bench mark at Greenbush, N. Y.	Elevation above mean tide at New York.
At Mindenville, N. Y ...... On the southeast corner of the bottom step of the east wing wall of the north abutment of the first bridge crossing the Erie Canal east of lock No. 34.	80.82	308.01	322.74
Near Mindenville, N. Y ...... The top of the projecting point of stone in the second course of the northwest wing of the north abutment of the third bridge crossing the Erie Canal west of lock No. 34 at Mindenville, N. Y. This corresponds with bench mark No. 35a of the United States Lake Survey, elevation 328.76.	81.84	314.28	329.01
Between Mindenville and Indian Castle, N. Y ...... A square cut on the east corner of the end stone in the third course of the southeast wing wall of the northeast abutment of bridge crossing the Erie Canal opposite the entrance of East Canada Creek to the Mohawk River.	82.56	314.87	329.60
At Indian Castle, N. Y ...... A square cut on the southeast corner of the most easterly capstone of the short retaining wall at the north end of the east wing of the Erie Canal aqueduct at Indian Castle, N. Y.	84.19	321.00	335.73
Between Indian Castle and Little Falls, N. Y ...... A square cut on the southeast corner of the capstone on the east end of the east wing wall of the north abutment of bridge crossing the Erie Canal at a point about 600 feet north of the Herkimer monument.	86.84	322.92	337.65
At Little Falls, N. Y ...... A cross cut on the top of an iron bolt in the coping of the southeast end of the northeast wall of the northeast lock of lock No. 36 of the Erie Canal. This corresponds to bench mark No. 37 of the United States Lake Survey, elevation 343 97.	88.51	329.57	344.30
At Little Falls, N. Y ...... A square cut on the south corner of capstone on the southwest end of the southwest wing of the northwest abutment of bridge crossing the Erie Canal at Bellinger street, Little Falls, N. Y.	89.59	363.58	378.31
Near Little Falls, N. Y ...... A circle cut on the southeast corner of capstone on the east end of the east wing of the north abutment of second bridge crossing the Erie Canal west of Bellinger Street Bridge at Little Falls, N. Y.	90.73	363.89	378.62
Between Little Falls and Herkimer, N. Y ...... Top of coping at the corner of the west wing wall of the north abutment of the first bridge crossing the Erie Canal east of lock No. 40. This corresponds to bench mark No. 38a of the United States Lake Survey, elevation 378.77.	91.75	364.34	379.07
Between Little Falls and Herkimer, N. Y ...... A cross cut on the top of the end bolt through the north branch of iron collar of the northeast gate of the north lock of lock No. 40 of the Erie Canal.	92.28	367.17	381.90
Near Herkimer, N. Y ...... A square cut on the southeast corner of capstone on the east end of the east wing wall of the north abutment of the second bridge over the Erie Canal east of lock No. 41 of the Erie Canal at Fort Herkimer.	94.29	370.86	385.59
At Herkimer, N. Y ...... A cross cut in a circle marked "U. S. D. W. B. M." on the top of the masonry near the northeast corner of the north abutment of the First Street Bridge at Herkimer, N. Y.	96.39	374.68	389.41
At Ilion, N. Y ...... Top of covering stone of masonry of northwest corner of culvert at southwest wing wall of the south highway bridge over the Mohawk River at Ilion, N. Y.	99.13	372.70	387.43
At Frankfort, N. Y ...... Top of the northwest corner of water table of pilaster, at West Shore R. R. roundhouse.	101.26	387.92	402.65
At Frankfort, N. Y ...... On top of projection of stone in bottom course of stones on the southeast corner of the northeast abutment of the first bridge crossing the Erie Canal east of lock No. 45 at Frankfort. This corresponds to bench mark No. 41 of the United States Lake Survey, elevation, 419.24.	101.66	404.85	419.58

PART I—Continued.

BENCH MARKS ESTABLISHED IN THE MOHAWK VALLEY, ETC.—Continued.

Dercription of location.	Distance from United States Coast Survey bench mark at Greenbush, N. Y., in miles.	Elevation above bench mark at Greenbush, N. Y.	Elevation above mean tide at New York.
Between Utica and Frankfort A copper nail in root of wild cherry tree about 500 feet southeast of milepost 200 from Buffalo on N. Y. C. and H. R. R. R.	104.22	394.64	409.37
Between Utica and Frankfort A copper nail in root of tree about 50 feet north of north rail of the N. Y. C. and H. R. R. R. and 200 feet east of culvert No. 496.	107.74	383.18	397.91
Near Utica, N. Y A copper nail in root of elm tree about 50 feet north of north bank of Mohawk River and about 830 feet northeast from north end of railroad bridge over Mohawk River on the Black River Branch of the N. Y. C. and H. R. R. R.	111.45	391.39	406.12
At Oriskany, N. Y A copper bolt flush with masonry on southwest corner of northwest coping stone of wing wall of Oriskany aqueduct, and marked "B. M. 19."	117.28	420.27	435.00
Between Rome and Oriskany Top of the southwest corner of the stone foundation of milepost 246 from New York and 194 from Buffalo of the N. Y. C. and H. R. R. R., about 1½ miles west of Oriskany station.	119.10	407.89	422.62
Between Rome and Oriskany Top of the southwest corner of the east abutment of bridge No. 538 of the N. Y. C. and H. R. R. R. Point on masonry above bridge seat, about 1 foot below top of rail and 5 feet south of south rail.	121.99	414.33	429.06
At Rome, N. Y A copper nail in root of elm tree about 20 feet east of east line of Lawrence street, Rome, N. Y., and about 900 feet north, measured along street from center of bridge crossing the old Erie Canal.	124.73	418.07	432.80
At Rome, N. Y Top of the southeast corner of the masonry about 1 foot below top of rail of bridge of the R., W. & O. R. R., crossing highway about 1 mile west of Rome, N. Y., near the Beet Sugar Co.'s buildings.	126.21	419.02	433.75
Between New London and Rome, N. Y. A copper nail in root of elm tree on the south side of the angle in the highway, and about 550 feet east, measured along the highway from the east side of the house of Mark Thron.	128.87	407.16	421.89
At New London, N. Y A copper nail in root of large elm tree in highway, about 75 feet south of the intersection of highways; also about 1,050 feet south of highway bridge crossing Wood Creek.	132.17	394.49	409.22
Between Sylvan Beach and New London A copper nail in south root of small tree in south corner of woods on the property of W. Warner, about 800 feet east of Drum Creek and about 500 feet west of east line of the W. Warner property.	135.69	367.75	382.48
Near Sylvan Beach, N. Y A copper nail in root of tree about 10 feet east of east right-of-way line of the N. Y., O. & W. R. R., and about 1,030 feet southwest, measured along the railroad from the south end of the railroad bridge crossing Fish Creek, about one-half mile east of Sylvan Beach, N. Y.	138.64	360.08	374.81
Near North Bay, N. Y A copper nail in root of oak tree 2 feet in diameter 12½ feet north of north right-of-way line of N. Y., O. and W. R. R. and 1,185 feet east of milepost marked "279."	142.13	408.18	422.91
Cleveland, N. Y A copper nail in root of maple tree 2½ feet in diameter 100 feet west of second highway crossing the N. Y., O. and W. R. R. west of railroad siding and 540 feet west of milepost marked "285."	148.45	409.19	423.92
Near Constantia, N. Y A copper nail in root of chestnut tree 2 feet in diameter 15 feet north of north right-of-way line of the N. Y., O. and W. R. R. and 305 feet east of railroad and highway intersection about one-half mile west of Constantia Railroad Station.	154.75	396.90	411.63
At Brewerton, N. Y A copper nail in root of elm tree on the north bank of the Oneida River about one-half mile east of the highway bridge and about 150 feet southeast of the house of Dr. Oberlander.	163.91	359.22	373.95

PART I—Continued.

BENCH MARKS ESTABLISHED IN THE MOHAWK VALLEY, ETC.—Continued.

Description of location.	Distance from United States Coast Survey bench mark at Greenbush, N. Y., in miles.	Elevation above bench mark at Greenbush, N. Y.	Elevation above mean tide at New York.
Near "High Banks," south of Caughdenoy, N. Y A copper nail in root of elm tree on the east bank of the Oneida River and on the west side of the highway about 850 feet northerly, measured on highway, from wooden bridge over Black Creek.	167.97	353.70	368.43
On Sand Ridge A copper nail in root of elm tree on property line between J. Ray and C. Breshnahan and about 1,000 feet westerly of highway, measured along property line.	169.70	370.48	385.21
Between Ingalls Crossing and Sand Ridge Top of masonry of northwest corner of south abutment of highway bridge crossing Bell Creek about 250 feet southeast of house of G. Hollenbeck.	176.7	362.59	377.32
Near Ingalls Crossing A copper nail in root of tree about 20 feet north of north right of-way line of N. Y., O. and W. R. R. and about 20 feet west of line fence between Chapman estate and A. Wolever; also about 3,400 feet west of west head block of siding at Ingalls Crossing.	179.7	362.09	376.82
At Phoenix, N. Y A copper nail in root of oak tree located about 750 feet southwest in the direction of highway from the intersection of highways about 200 feet east of bridge over Brandy brook and about 150 feet southeast, at right angles to highway, from this highway; also about 450 feet north of north edge of Oswego Canal.	173.34	344.26	358.99
At Hinmanville, N. Y Copper bolt, flush with masonry, between anchors on lower hollow quoin (towpath side) of lock No. 6, Oswego Canal.	176.31	346.89	361.62
Between Fulton and Hinmanville, N. Y Copper bolt, flush with masonry, between anchors on middle hollow quoin (towpath side) of lock No. 7, Oswego Canal.	178.64	339.73	354.46
At Fulton, N. Y Copper bolt, flush with masonry, on first step of south wing wall of east abutment of highway bridge on North First street.	184.01	308.69	323.42
Between Minetto and Fulton Copper bolt, flush with masonry, between anchors on middle hollow quoin (towpath side) of guard lock No. 4, Oswego Canal.	186.64	298.26	312.99
At Minetto, N. Y Copper bolt, flush with masonry, between anchors on northeast lower hollow quoin (towpath side) of lock No. 13, Oswego Canal.	189.78	287.50	302.23
Between Oswego and Minetto, N. Y Copper bolt, flush with masonry, between anchors on northeast lower hollow quoin (towpath side) of lock No. 15, Oswego Canal.	191.96	272.90	287.63
At Oswego, N. Y Top of iron bolt in top of masonry of old Government pier at the foot of West Third street, 0.5 foot from east face of pier, 3.5 feet north of north line of wooden dock leading to boathouse. Bolt is sunk one-half inch below top of masonry, and the letters "U. S." are obliterated by fresh masonry. This corresponds to bench mark "A" (Oswego) of the United States Lake Survey, elevation 251.96.	194.92	238.12	252.85

BENCH MARKS FROM WATERFORD, N. Y., TO PORT HENRY, N. Y., ALONG HUDSON RIVER, D. & H. C. CO.'S R. R., AND LAKE CHAMPLAIN.

At Waterford, N. Y Bench mark is an arrow cut on southwest corner of bridge seat of north abutment of D. and H. R. R. bridge over the fourth branch of Mohawk River.	12.1	15.89	30.62
At Waterford, N. Y Bench mark is a square cut on south end of stone doorsill west entrance of D. and H. Canal Co.'s R. R. passenger depot.	12.6	21.84	36.57

Part I—Continued.

BENCH MARKS FROM WATERFORD, N. Y., TO PORT HENRY, N. Y., ETC.—Continued.

Description of location.	Distance from United States Coast Survey bench mark at Greenbush, N. Y., in miles.	Elevation above bench mark at Greenbush, N. Y.	Elevation above mean tide at New York.
3.5 miles north of Waterford Bench mark is a square cut in east end of stone window sill of west cellar window on south side of George S. Force's road house. Building is on east side of Waterford and Whitehall turnpike road.	15.9	38.38	53.11
Mechanicville Bench mark is a square cut on north end of stone window sill of the most northerly window on west face of Hudson River Power Transmission Co.'s power house.	18.5	47.36	62.09
Mechanicville Square cut in surface of concrete masonry of sluice gates near southwest corner of same and at west end of weir of H. R. P. T. Co.'s dam.	18.6	42.11	56.84
Mechanicville Bench mark is square cut near south end of sill of basement window between tower and main entrance of Presbyterian church, on Main street.	20.0	74.60	89.33
Mechanicville Notch cut on angle of stone water table northeast corner of main building of Methodist Episcopal Church, Main street.	20.1	74.79	89.52
Mechanicville Square cut on north end of stone doorsill of south door on west front of chipping mill at Duncan Co.'s pulp and paper mills.	21.3	78.36	93.09
Between Mechanicville and Stillwater Bench mark is head of bolt at base of first south column just east of electric railroad tracks at west end of Fitchburg R. R. bridge crossing Hudson River.	22.1	72.26	86.99
Stillwater Is square cut on large flat stone step at entrance of First Methodist Episcopal Church. Square is on south end of stone.	23.6	75.26	89.99
Between Stillwater and Schagticoke Bench mark is a spike in bench cut in root on west side of elm tree. The tree is on the right bank of the Hoosick River, about 200 feet from water's edge in main channel and about 1,000 feet downstream from the mouth of the Tourhannock Creek.	26.3	86.07	100.80
Bemis Heights Is top of iron bolt leaded in southeast corner of top stone at north abutment of sluice gate of Champlain Canal. Sluice gate is near iron truss canal bridge No. 36.	27.1	89.47	104.20
Bemis Heights Bench mark is square cut on southwest corner of stone in lower course of south end of east abutment of iron truss canal bridge No. 39 and about 5,000 feet north of Bemis Heights.	28.1	91.30	106.03
Wilbur's Basin Bench mark is square cut on southwest corner of stone at north end of semicircular coping on stone work of outlet of basin.	29.3	88.30	103.03
Between Wilbur's Basin and Coveville Bench mark is a circle painted with red paint on northeast corner of top stone on east end, north abutment of sluice gate on Champlain Canal, 1.7 miles north of Wilbur's Basin, established by United States Geological Survey.	31.0	89.44	104.17
Coveville Is circle cut on northeast corner of east stone of second course above surface of ground, south abutment of Champlain Canal bridge No. 54. Bridge is about 1,000 feet east of Coveville post-office.	34.1	92.05	106.78
Schuylerville Bench mark is a circle cut on northeast corner of north stone of third course from ground of north wing wall of east abutment of canal bridge No. 60, Ferry street, Schuylerville.	37.2	92.16	106.89
Schuylerville Bench mark is a square cut on southeast corner of stone south end of second course of masonry above water surface of south wing wall west abutment Champlain Canal bridge No. 62. This bridge is on the road leading to new iron bridge over Hudson River.	38.3	90.61	105.34

PART I—Continued.

BENCH MARKS FROM WATERFORD, N. Y., TO PORT HENRY, N. Y., ETC.—Continued.

Description of location.	Distance from United States Coast Survey bench mark at Greenbush, N. Y., in miles.	Elevation above bench mark at Greenbush, N. Y.	Elevation above mean tide at New York.
Northumberland Bench mark is square cut in southeast corner of south stone of top course of masonry at south end of east wall of lock No. 10, Champlain Canal.	39.0	95.34	110.07
Fort Miller Bench mark is square cut on south end of stone sill to south window in front of brick blacksmith shop on east side of highway along east bank of Hudson River and about 1,700 feet north of Thorp & Wegman's pulp mill.	41.8	109.48	124.21
Moses Kill Bench mark is a square cut in northwest corner of north stone in second course above ground of west abutment of Champlain Canal bridge just north of aqueduct.	45.0	128.14	142.87
Snook Kill Bench mark is a square cut in northeast corner of north stone third course above ground west abutment of canal bridge across the river from and about 600 feet south of the mouth of Snook Kill.	47.1	128.20	142.93
Fort Edward United States Geological bench mark is a nickel plate about 5 inches diameter set in wall north side of west entrance of high-school building.	49.8	130.80	145.53
Dunham's Basin Bench mark is square cut in northwest corner of west stone of the top course of masonry of south abutment of plate-girder bridge carrying D. & H. R. R. over canal overflow about 600 feet south of highway crossing.	53.2	131.95	146.68
Smith's Basin Bench mark is square cut on northwest corner of west stone of top course of masonry of south abutment of small plate-girder bridge on D. & H. R. R. bridge just north of railroad station.	57.7	127.81	142.54
Fort Ann Bench mark is a cross chiseled in the coping of parapet wall to north abutment of D. & H. R. R. bridge across Wood Creek. Cross is near north edge of stone and directly opposite space between the two bridges.	62.0	125.63	140.36
Comstock's post-office Bench mark is square cut in southeast corner of south stone of coping of culvert and on east side of roadbed of D. & H. R. R. about 2,800 feet south of station.	65.1	117.35	132.08
Between Comstock's post-office and Whitehall Bench mark is a square cut in southeast corner of stone south abutment of D. & H. R. R. bridge over Champlain Canal on west side at north end of plate girder, where it connects with middle truss of bridge.	68.1	119.93	134.66
Whitehall Bench mark is a square cut on east stone top course of south abutment canal sluice 1,100 feet south of bridge of Rutland Branch D. & H. R. R. over canal.	72.3	108.96	123.69
Whitehall United States Coast and Geodetic bench mark No. 36 is a circle cut on west wall of lower lock just north of hollow quoin of lower gate and marked "U. S. Coast Survey Elev.—104.71."	73.2	79.82	104.55
Whitehall Is square cut on shelf of rock about 1 foot above ground in east side of second rock cut north of the town near the middle of the cut. The rock wall is marked 1 foot above bench mark by chiseled letters "U. S. B. M."	74.7	93.40	108.13
Snody Dock Bench mark is a square cut on northwest corner of north stone of coping of culvert and is on west side of roadbed of D. & H. R. R., about 1,000 feet south of Snody Dock.	78.6	91.94	106.67
Chubb's Dock Bench mark is square cut on southeast corner of east large stone at top course of north abutment of small plate-girder bridge No. 5 on D. & H. R. R., about 400 feet north of station.	80.6	92.54	107.27
Dresden Station Bench mark is square cut on southwest corner of south stone of coping of arch culvert on west side of roadbed of D. & H. R. R. Culvert is about 1,900 feet north of railway station.	82.8	93.25	107.98

PART I—Continued.

BENCH MARKS FROM WATERFORD, N. Y., TO PORT HENRY, N. Y., ETC.—Continued.

Description of location.	Distance from United States Coast Survey bench mark at Greenbush, N. Y., in miles.	Elevation above bench mark at Greenbush, N. Y.	Elevation above mean tide at New York.
Putnam Station .... Bench mark is cut on ledge of rock on the west side of railroad track near the north end of the first rock cut south of the station. It consists of the letters "B. M." and a cross and circle chiseled into the rock. This bench mark was established by the United States Coast Survey and numbered 39, Coast Survey Elev. = 108.46.	88.4	92.89	107.62
Putnam Station .... Bench mark is square cut on southeast corner of south stone of coping west face of large culvert on D. & H. R. R. about 1,900 feet north of station.	89.0	91.52	106.25
Wright's .... Bench mark is square cut in northeast corner of second course of masonry from top south abutment of bridge No 16, D. & H. R. R., about 1,800 feet north of Wright's Station.	93.5	93.89	108.62
Fort Ticonderoga .... Bench mark is square cut on southwest corner of masonry projection of water tank south of Fort Ticonderoga depot.	95.0	94.83	109.56
Ticonderoga .... Is circle with hole in center in large stone on southeast corner of north abutment of D. & H. R. R. drawbridge No. 19 over Ticonderoga Creek near its mouth. Bench mark is marked "U. S. G. S. B. M."	97.8	95.63	110.36
Between Addison Junction and Crown Point .... Bench mark is a square cut on southeast corner of east coping of culvert on D. & H. R. R. over creek entering Lake Champlain about 2,200 feet south of Five Mile Point.	101.9	93.14	107.87
Crown Point Station .... Bench mark is a square cut on surface of coping south end of east wing wall of south abutment of bridge No. 23 on D. & H. R. R. bridge over Putnam Creek about 2,800 feet north of railroad station.	106.5	99.67	114.40
Fort Frederick .... Bench mark is lead bolt in center of pyramid cut on natural rock outcrop in center of thornbush thicket about 1,600 feet south of the ruins of old English fort and about 1,700 feet west of highway. Bench mark is the north base of Crown Point base line and is marked "U. S. C. S. Base Line, 1872."	110.3	147.41	162.14
Crown Point Light-House .... Bench mark is square cut in masonry on the east side just south of corner of second course above ground of light-house at Crown Point.	110.4	116.09	130.82

BENCH MARKS ESTABLISHED ALONG LAKE CHAMPLAIN BETWEEN COOPERVILLE AND FORT MONTGOMERY, N. Y.

At Cooperville, N. Y .... The center of a square cut in the southwest corner of the coping stone on the southwest corner of the center pier of the Delaware and Hudson R. R. bridge over the Great Chazy River near Cooperville, N. Y.	174.30	88.31	103.04
At Legget's Crossing .... A point in square on iron pin in coping stone on the west side of Delaware and Hudson R. R. track 2 feet west of the west side of opening and 6 inches back from north edge of culvert about 800 feet south of Legget's Crossing, which is about 1.5 miles north of Cooperville, N. Y.	175.85	119.01	133.74
At Rouse Point, N. Y .... On the water table on the north side of the Chapman Block building 20.6 feet west from the northeast corner on the west side of Lake street and on the south side of Chapman street, and is 1.6 feet above the ground. This corresponds to the bench mark established at Rouse Point by the United States Coast and Geodetic Survey, elevation 110.08.	178.70	94.22	108.95
At Fort Montgomery, N. Y .... Level of the base of scarp wall on the north face of bastion B. Fort Montgomery, about 3 feet from the angle with the east curtain of the fort, and corresponds with the United States Engineers' bench mark at this point.	180.00	80.27	95.00

PART I—Continued.

BENCH MARKS ESTABLISHED BETWEEN LAKE CHAMPLAIN AND LAKE ST. FRANCIS, VIA CHAMPLAIN, BARRINGTON, ORMSTOWN, AND ST. STANISLAS.

Description of location.	Distance from United States Coast Survey bench mark at Greenbush, N. Y., in miles.	Elevation above bench mark at Greenbush, N. Y.	Elevation above mean tide at New York.
At Cooperville, N. Y. The center of a square in the southwest corner of the coping stone on the southwest corner of the center pier of the Delaware and Hudson R. R. bridge over the Great Chazy River, near Cooperville, N. Y.	174.30	88.31	103.04
Between Coopersville and Champlain, N. Y A nail driven in the root of the southwest side of elm tree 3½ feet in diameter, standing on the south side of highway on the east side of the Great Chazy River. It is about 7,500 feet from the Oak Street Bridge at Champlain, N. Y., as measured along the highway, and about 900 feet east of the east bank of the river.	177.26	118.11	132.84
At Champlain, N. Y On a 2-inch square cut in the top of the first step above the main abutment on the west side of the north abutment of the Oak Street Bridge over the Great Chazy River at Champlain, N. Y.	178.60	94.78	109.506
Near Champlain, N. Y On a 1½-inch square cut in the stone step near the east side of the front door to the Champlain Waterworks, about 1 mile north of the city.	180.00	150.25	164.98
Between Champlain, N. Y., and Barrington, Province of Quebec, Canada A nail in the root on the west side of elm tree 1½ feet in diameter, on the north side of the Great Chazy River, about 2.6 miles northwest of Champlain, N. Y. It is about 80 feet west of small creek about 1,400 feet north of the north bank of the Great Chazy River and about 730 feet south of the international boundary line.	181.20	156.41	171.14
Between Champlain, N. Y., and Barrington, Province of Quebec A square, 1½ inches on a side cut in the top of a bowlder about 50 feet south of barn on property of Jas. Straps, located about 5.6 miles northwest of Champlain, N. Y. It is about 1,360 feet east of the intersection of the highway running north and south with the road to Hemmingford.	184.23	183.88	198.61
Near Barrington, Province of Quebec A nail in the root on the northeast side of elm tree 2 feet in diameter, on the property of Jos. Robinson, about 50 feet east of the Little Montreal River and about 550 feet north of east and west highway about 2.7 miles south of Barrington, N. Y., and 300 feet west of the north and south highway.	187.80	194.11	208.84
At Barrington, Province of Quebec A nail in the root on the west side of elm tree 2½ feet in diameter, on the west side of the highway running northeast and southwest through Barrington, N. Y., and is about 2,400 feet southwest of the crossing of this highway with the Grand Trunk R. R.	190.30	174.60	189.33
Between Barrington and St. Clothilde, Province of Quebec A nail in the root on the northwest side of maple tree 10 inches in diameter, on the south side of the right of way of the Canada and Atlantic R. R., and 150 feet east of east end of bridge over Cranberry Creek, about 3 miles west of Barrington, N. Y.	193.30	162.89	177.62
Near St. Clothilde, Province of Quebec A nail in the root on the north side of elm tree 8 inches in diameter, about 100 feet south of south right of way line of the Canada and Atlantic R. R., and about 600 feet west of Holton R. R. station, which is about 1½ miles southeast of St. Clothilde, Province of Quebec.	195.40	183.03	197.76
Between St. Clothilde and Aubrey, Province of Quebec A nail in the root on the south side of elm tree 16 inches in diameter, about 40 feet north of north right of way line of the Canada and Atlantic R. R. and about 750 feet west of the first highway crossing west of Holton station.	197.70	158.15	172.88
At Aubrey, Province of Quebec A nail in the root on the west side of ash tree 14 inches in diameter, about 80 feet south of the south bank of the English River and about 500 feet north of the intersection of highways at Aubrey.	201.70	121.40	136.13

PART I—Continued.

BENCH MARKS ESTABLISHED BETWEEN LAKE CHAMPLAIN AND LAKE ST. FRANCIS, VIA CHAMPLAIN, BARRINGTON, ETC.—Continued.

Description of location.	Distance from United States Coast Survey bench mark at Greenbush, N. Y., in miles.	Elevation above bench mark at Greenbush, N. Y.	Elevation above mean tide at New York.
Between Anbrey and Ormstown, Province of Quebec A nail in the root on the south side of oak tree 18 inches in diameter, on the Fertile Creek road about 3.6 miles west of Aubrey and about 700 feet southwest of the culvert on this highway over Fertile Creek.	205.30	118.57	133.30
At Ormstown, Province of Quebec The center of a 1½-inch square cut in the top of coping stone near the northwest corner of the east abutment of the highway bridge over the Chateauguay River at Ormstown, Province of Quebec.	212.4	123.97	138.70
Between Ormstown and St. Stanislas, Province of Quebec A nail in the root on the west side of poplar tree 2 feet in diameter, on the south side of highway at a point about 750 feet west of the intersection of highways about 4 miles northwest of highway bridge at Ormstown, Province of Quebec.	216.3	141.67	156.40
At St. Stanislas, Province of Quebec On the top of horizontal offset of water table, which is about 1 inch below the top of the west doorstep of the St. Stanislas Roman Catholic Church. It is on top of angle at the east side of pilaster near the southwest corner of the church, and the angle at the bench mark is 5½ feet west of the west doorstep of the church. There are no marks to indicate the location of the bench mark.	220.3	150.93	165.66
On shore of Lake St. Francis On a 1½-inch square marked "B. M.," cut in the top of ledge of limestone about 64 feet from lake shore on a point of land projecting into Lake St. Francis, about 2,150 feet west of the intersection of highway running northwest from St. Stanislas with highway, near the lake shore and about 2.7 miles from St. Stanislas railroad station.	222.9	142.71	157.44
Valleyfield Coping of north wall of lock No. 14, Beauharnois Canal. Bench mark is on the iron bolt in strap, 6 inches from heel post of upper gate.	228.9	140.95	155.68

BENCH MARKS ESTABLISHED BETWEEN ST. STANISLAS, PROVINCE OF QUEBEC, CANADA, AND HOGANSBURG, N. Y.

At St. Stanislas, Province of Quebec On the top of horizontal offset of water table, which is about 1 inch below the top of the west doorstep of St. Stanislas Roman Catholic Church. It is on top of angle at the east side of pilaster near the southwest corner of the church, and the angle at the bench mark is 5½ feet west of the west doorstep of the church. There are no marks to indicate the location of the bench mark.	220.3	150.93	165.66
At Huntingdon, Province of Quebec On the top of iron monument on the southeast corner of the first street intersection south of the Grand Trunk R. R. depot at Huntingdon, Province of Quebec.	226.7	145.22	159.95
At Carrs Crossing Province of Quebec A nail in the root on the west side of elm tree 14 inches in diameter, 160 feet north of the center of track of the Grand Trunk R. R., and 360 feet east of road at Carrs Crossing.	231.8	169.02	183.75
At Whites Station, Province of Quebec A nail in the root on the north side of maple tree 14 inches in diameter, 20 feet south of the center of track of the Grand Trunk R. R., and 3 feet east of the east road fence at Whites station.	233.3	165.10	179.83
At St. Agnes station, Province of Quebec A nail in the root on the north side of elm tree 20 inches in diameter, 60 feet from the center of track of the Grand Trunk R. R., in the east fence line of the road east of St. Agnes station.	238.8	183.89	198.62
At Fort Covington, N. Y A 2-inch square 1 foot from the south edge and 1 foot from the east edge of the east abutment of the Grand Trunk R. R. bridge over the Salmon River at Fort Covington, N. Y.	244.3	152.74	167.47

PART I—Continued.

BENCH MARKS ESTABLISHED BETWEEN ST. STANISLAS, PROVINCE OF QUEBEC, CANADA, AND HOGANSBURG, N. Y.—Continued.

Description of location.	Distance from United States Coast Survey bench mark at Greenbush, N. Y., in miles.	Elevation above bench mark at Greenbush, N. Y.	Elevation above mean tide at New York.
At Hogansburg, N. Y The center punch mark in one fourth-inch brass bolt cemented into the northeast face of the east buttress of the main tower of St. Patrick's Catholic Church, Hogansburg, N. Y. The bolt is 21 inches below the water table and 18 inches above the ground. The letters "U. S. P." are cut into the foundation masonry. This bench mark is designated as United States precise bench mark "P" on the line of precise levels between Hogansburg and Cape Vincent.	252.8	164.55	179.28

BENCH MARKS ESTABLISHED BY PRECISE LEVELS BETWEEN HOGANSBURG, N. Y., AND ST. REGIS, CANADA.

At Hogansburg, N. Y The center punch mark in one fourth inch brass bolt cemented into the northeast face of the east buttress of the main tower of St. Patrick's Catholic Church at Hogansburg, N. Y. The bolt is 21 inches below the water table and 18 inches above the ground. The letters "U. S. P." are cut into the foundation masonry.	252.8	164.55	179.28
At Hogansburg, N. Y The center punch mark in one-fourth inch brass bolt cemented into the southeast face 1 foot from the east corner of the Catholic convent at Hogansburg. The bolt is in the limestone water table about 2 feet above the surface of the ground and the letters "U. S. C." are cut into the stone.	253.0	166.24	180.97
At St. Regis, Canada The center punch mark in one-fourth inch brass bolt cemented into the west side of the northwest corner of tower of St. Regis Catholic Church 10 inches from said corner and about 19 inches above the surface of the ground. The letters "U. S. A." are cut into the stone.	255.2	156.14	170.87
At St. Regis, Canada The center punch mark in one-fourth inch brass bolt cemented into the south face and 6 inches from the southwest corner of the priest's house opposite the Catholic Church at St. Regis, Canada. The bolt is 6 inches above the surface of the ground and the letters "U. S. B." are cut into the foundation stone.	255.2	153.18	167.91

BENCH MARKS ESTABLISHED BY PRECISE LEVELS ALONG THE ST. LAWRENCE RIVER BETWEEN HOGANSBURG, N. Y., AND CAPE VINCENT, N. Y.

Hogansburg, N. Y The center punch mark in one-fourth inch brass bolt cemented into the northeast face of the east buttress of the main tower of St. Patrick's Catholic Church at Hogansburg. The bolt is 21 inches below the water table and 18 inches above the ground. The letters "U. S. P." are cut into the foundation masonry.	252.8	164.55	179.28
Between Hogansburg and Louisville Landing, N. Y The top of a roundheaded brass bolt set in a concrete base about 350 feet northwest of the northwest bank of the Racket River, and 20.5 feet southeast of a large pine tree, 9 feet in circumference, and blazed 12 by 17 inches. The tree is the largest pine tree near the mouth of the Racket River, and the blaze is marked the same as the concrete base, "U. S. P. B. M. 1." The bench mark is covered by about 1 foot of earth.	254.8	158.17	172.90
Between Hogansburg and Louisville Landing, N. Y The top of a roundheaded brass bolt set into a concrete base on the north side of the Grass River road, just east of the mouth of the Grass River. The bench is 3 feet south of the north fence line of the road, and on the west fence line of house lot of Wm. Tucker. The bench was set 1.2 feet underground, and marked on the concrete base "U. S. P. B M. 2."	258.5	194.28	209.01

PART I—Continued.

BENCH MARKS ESTABLISHED BY PRECISE LEVELS ALONG THE ST. LAWRENCE RIVER BETWEEN HOGANSBURG, N. Y., AND CAPE VINCENT, N. Y.—Continued.

Description of location.	Distance from United States Coast Survey bench mark at Greenbush, N. Y., in miles.	Elevation above bench mark at Greenbush, N. Y.	Elevation above mean tide at New York.
Between Hogansburg and Louisvile Landing, N. Y The top of a roundheaded brass bolt set into a concrete base 3 feet south of fence on the north side of the river road, and in the center of the north and south road, branching off from the river road, opposite the farm of John Wood. The bench is 25 feet east of a honey locust hedge on the west line of said farm, and is 1.3 feet under the surface of the ground. The concrete base is marked "U. S. P. B. M. 3."	261.5	190.67	205.40
Between Hogansburg and Louisville Landing, N. Y The top of a roundheaded one fourth inch brass bolt set into a concrete base underground and situated on the south side of the river road on line of a stone fence running north and south opposite the barnyard of Frank Polly's farm. The bench is 5.5 feet from the south fence of the road and 420 feet east of Polly's Creek and is marked on the concrete base "U. S. P. B. M. 4."	264.4	207.67	222.40
Between Hogansburg and Louisville Landing, N. Y The top of a roundheaded one-fourth inch brass bolt set into a concrete base 1.2 feet below the surface of the ground and situated on the north side of the river road at the corner of the fence in the turn of the road at the house of Norman Hopson. The bench is 2.8 feet from the fence corner and is marked "U. S. P. B. M. 5."	267.1	233.65	248.38
Near Louisville Landing, N. Y The top of a roundheaded one-fourth inch brass bolt set into a concrete base 1.3 feet underground, 3 feet north of north and south fence line of the river road and 58.5 feet east of the east fence of Isaac Richards's residence at Richards's Landing. The bench is marked on the concrete base "U. S. P. B. M. 6."	269.8	218.68	233.41
At Louisville Landing, N. Y The center punch mark in a one-fourth inch brass bolt cemented into the west face of the hotel of R. B. Mathews at Louisville Landing, 2 6 feet from the northwest corner of the building in a foundation stone 0.9 foot above ground marked "U. S."	272.3	216.31	231.04
Between Louisville Landing and Waddington, N. Y The top of a roundheaded one-fourth inch brass bolt set into a concrete base 1.4 feet underground and situated on the north side of the river road, 22.7 feet west and on west fence line of Chas. Whalen's house. The bench is 3 feet east of said Whalen fence and on the north fence line of the river road and is marked "U. S. P. B. M. 7."	274.7	210.51	225.24
Between Louisville Landing and Waddington, N. Y The top of a roundheaded one-fourth inch copper bolt set into the top of a large granite bowlder in the orchard on the north side of the river road on the crest of hill, 6.8 feet north of north fence line of River road, opposite the home of William Bradford, on Bradford's Hill. The bowlder is marked "U. S. P. B. M. 8."	276.8	245.71	260.44
Between Louisville Landing and Waddington, N. Y The top of a roundheaded one fourth inch brass bolt set into a concrete base 1.2 feet below the ground, on the north side of the river road abreast of Egg Island (or Rutherfords or Carrs Island), in Cole's Creek. The bench is nearly on said north road line and 5.8 feet south of the south corner of a large wooden barn of Wm. Hosmer, and on the concrete base is marked "U. S. P. B. M. 9."	279.0	225.12	239.85
Near Waddington, N. Y The top of a roundheaded one-fourth inch brass bolt set into a concrete base covered by 1.2 feet of earth and situated on the north side of the river road 4.2 feet south of the north fence line, and on the property line between Dartis and Scott lots, abreast of Murphys Island. The concrete base is marked "U. S. P. B. M. 10."	281.6	222.56	237.29
At Waddington, N. Y The center punch mark in one-fourth inch brass bolt cemented into the south buttress of the steeple, 12 feet northeast from the center of the main entrance, 1 6 feet from the outer corner of said buttress and 1.5 feet above the ground, on the Presbyterian Church at Waddington, N. Y., and marked "U. S. A."	284.3	259.18	273.91

PART I—Continued.

BENCH MARKS ESTABLISHED BY PRECISE LEVELS ALONG THE ST. LAWRENCE RIVER BETWEEN HOGANSBURG, N. Y., AND CAPE VINCENT, N. Y.—Continued.

Description of location.	Distance from United States Coast Survey bench mark at Greenbush, N. Y., in miles.	Elevation above bench mark at Greenbush, N. Y.	Elevation above mean tide at New York.
At Waddington, N. Y. The center punch mark in one-fourth inch brass bolt cemented into the foundation masonry on the northeast face, 1.9 feet from the north corner and 0.8 foot above the ground on the town hall at Waddington, N. Y., and marked "U. S. B."	284.5	262.36	277.09
At Waddington, N. Y. The center punch mark in one-fourth inch brass bolt cemented into the upper foundation stone 3 inches from the south corner and 24 inches above the ground on the southwest face of St. Paul's Episcopal Church at Waddington, N. Y. The letters "U. S. 11" are cut into the stone.	284.5	264.70	279.43
Between Waddington and Ogdensburg, N. Y. The top of a roundheaded one-fourth inch brass bolt cemented into the top of a large granite bowlder on the south side of the river road at the turn just west of point Three Points (better known as White House Point or Waddels Point). The bowlder forms the end of a stone wall near the entrance to the property of Waddel and is marked "U. S. P. B. M. 12."	287.8	239.59	254.32
Between Waddington and Ogdensburg, N. Y., at Tilden post-office. The top of a roundheaded one-fourth inch brass bolt cemented into the top of a bowlder on the north side of the river road and on the east property line of Tilden post-office, just opposite Iroquois Point. The bowlder is marked "U. S. P. B. M. 13 A."	290.8	259.72	274.45
Between Waddington and Ogdensburg, at Tilden post-office The center punch mark in one-fourth inch brass bolt cemented into foundation stone of Tilden post-office, situated on the north side of the river road on the town line between Lisbon and Waddington, N. Y. The mark is on the southeast face of the building, 7.2 feet from the south corner and 0.8 foot above the ground. The letters "U. S." are cut into the stone.	290.8	256.25	270.98
Between Waddington and Ogdensburg, N. Y. The top of a roundheaded one-fourth inch brass bolt set into a concrete base, covered by 1 foot of earth, on the north side of the river road at a turn in the fence on the east property line of Siles Samon's property. The bench is 7 feet west from a large sugar maple tree, blazed and marked "U. S." The concrete base is marked "U. S. P. B. M. 14."	294.1	259.82	274.55
Between Waddington and Ogdensburg, N. Y., at Lisbon post-office The center punch mark in one-fourth inch brass bolt cemented into the corner stone on the west corner of the Episcopal stone church at Lisbon post-office, 7 miles below Ogdensburg, N. Y. The church is on the south side of the river road. The bench is on the north face of the church, 10 inches from the west corner, 28 inches above the ground, and is marked "U. S. 15."	296.7	265.02	279.75
Near Ogdensburg, N. Y. The center punch mark in one-fourth inch brass bolt cemented into red sandstone coping on the north side of infirmary building in New York State Hospital grounds, below Ogdensburg, N. Y. The mark is 12.7 feet from the west corner of said building, and 50.5 feet from the center of doorway on the north side, and is 4 feet above the ground. The letters "U. S." are cut into the coping stone over the bench mark.	300.6	268.53	283.26
At Ogdensburg, N. Y. The punch mark on the center of a one-fourth inch brass bolt cemented into a 12 by 18 inch red sandstone on the southwest corner of the Armory Building, Ford street, Ogdensburg, N. Y., 34 inches above the surface of the ground. The letters "U. S. A." are cut into the masonry.	304.0	264.20	278.93
At Ogdensburg, N. Y. The punch mark in the center of one-fourth inch brass bolt cemented into a 12 by 18 inch foundation stone on the southeast face of the town hall and opera house, corner of Ford and Caroline streets, Ogdensburg, N. Y. The mark is on the west half of said face and 6.25 feet from the southwest corner of the building and 2.25 feet above the surface of the ground. The letters "U. S. B." are cut into the masonry.	304.0	267.04	281.77

PART I—Continued.

BENCH MARKS ESTABLISHED BY PRECISE LEVELS ALONG THE ST. LAWRENCE RIVER BETWEEN HOGANSBURG, N. Y., AND CAPE VINCENT, N. Y.—Continued.

Description of location.	Distance from United States Coast Survey bench mark at Greenbush, N. Y., in miles.	Elevation above bench mark at Greenbush, N. Y.	Elevation above mean tide at New York.
At Ogdensburg, N. Y. The center punch mark in one-fourth inch brass bolt cemented into a corner coping stone on the northeast corner of the United States custom-house, State street, Ogdensburg, N. Y. The mark is 7¼ inches west of said corner of building, on the north face, 4 feet and one-half inch above the sidewalk. The letters "U. S. C." are cut into the coping stone.	304.0	276.17	290.90
At Ogdensburg, N. Y. The center punch mark in one-fourth inch brass bolt cemented into coping stone on the north face of the United States light-house on the west pier at the mouth of the Oswegatchie River, Ogdensburg, N. Y. The mark is 48¼ inches southwest of the north corner of the house and 32¼ inches above the surface of the ground. The letters "U. S. D." are cut into the coping stone.	304.5	237.32	252.05
Near Ogdensburg, N. Y. The top of a roundheaded one-fourth inch brass bolt set into a concrete base, 12 inches below the surface of the ground, 31.7 feet south of the center of track of the Utica and Black River R. R., near Nevins Point, 3 miles above Seymour House, Ogdensburg, N. Y. The bench is 25.5 feet north of a large elm tree (30 inches diameter), blazed and marked "U. S.," also about 200 feet south of a stone ice house and about 250 feet northeast of a stone barn. The concrete base is marked "U. S. P. B. M. 17," and the same letters are cut into a large bowlder in the corner of the fence about 10 feet northwest of the bench	306.9	245.69	260.42
Between Ogdensburg and Morristown, N. Y. The top of a square-headed one-fourth inch brass bolt cemented into bed rock 6 inches under ground, about 900 feet northwest from house of Le Rock, 45.6 feet northwest of center of track of Utica and Black River R. R., 292.5 feet northeast of section post 23–24 of this railroad, 6 miles above Seymour House, Ogdensburg, N. Y. The bench is 124 feet west of a wagon road leading from Le Rock's house to the St. Lawrence River and about 200 feet southwest from a small stone boathouse on the river bank. The letters "U. S. P. B. M. 18" are cut into the bed rock.	309.8	235.35	250.08
Near Morristown, N. Y. The top of a roundheaded one-fourth inch brass bolt cemented into bed rock, 25.8 feet northwest from center line of track of the Utica and Black River R. R., 52 feet southeast of a ledge of rock on the St. Lawrence River bank, on Dows Point, 20° NW., a distance of about 1,000 feet from the residence of Geo. Beattie, 9 miles above Ogdensburg and about 2 miles below Morristown. The bench is 331 feet southwest from the southwest corner of summer cottage "Rock Ledge," E. 50° S. from Brockville Asylum, Canada, and 60 feet northwest from a blazed telegraph pole. The letters "U. S. P. B. M. 19" are cut into the bed rock, which is covered by 6 inches of earth.	312.7	235.65	250.38
At Morristown, N. Y. The center punch mark in a one-fourth inch brass bolt cemented into coping stone on the northwest corner of lumber office of the Gillies Bros. Co., Limited, in the northwest end of Morristown, N. Y. The building is of limestone and is owned by Frank Chapman, Ogdensburg, N. Y. The bench mark is on the north face of said building, 6 inches from the northwest corner and about 18 inches above the ground. The bench is marked "U. S. A."	314.7	258.99	273.72
At Morristown, N. Y. The center punch mark in a one-fourth-inch brass bolt cemented into a corner stone of the foundation masonry of a stone warehouse 68 feet west and across the road from P. B. M. A. The bench is on the east face of said building, 8 inches from the southeast corner, and the letters "U. S. B." are cut into the stone. The bench is also 79.5 feet from the north side of the United States custom-house and 117 feet east of the center of main track of the Utica and Black River R. R.	314.7	257.59	272.32

PART I—Continued.

BENCH MARKS ESTABLISHED BY PRECISE LEVELS ALONG THE ST. LAWRENCE RIVER BETWEEN HOGANSBURG, N. Y., AND CAPE VINCENT, N. Y.—Continued.

Description of location.	Distance from United States Coast Survey bench mark at Greenbush, N. Y., in miles.	Elevation above bench mark at Greenbush, N. Y.	Elevation above mean tide at New York.
Between Morristown and Oak Point, N. Y. The top of a roundheaded one-fourth inch brass bolt cemented into a slab of limestone rock embedded in sand and gravel near the shore of the St. Lawrence River, on the east side of a small bay, 1.6 miles above Morristown, and on range with the upper end of old Main Island and Umbrella Island. The bench is at the foot of a ledge of rock at Rowleys or Housers Point, 6 feet from the face of a ledge and about 180 feet north of the river road. The letters "U. S. P. B. M. 20" are cut into the rock.	316.6	233.03	247.76
Between Morristown and Oak Point, N. Y. The top of a roundheaded one-fourth inch brass bolt cemented into the top of a bowlder (5 by 3 feet) projecting 2 feet above the surface of the ground and situated on the north side of the river road, in a turn of this road, and opposite the center of a cross road running southeast from the river road and about three-fourths of a mile east of town line between the towns of Morristown and Hammond; 2¼ miles northeast from Oak Point, or 1,000 meters northeast from the cross road known as the Blackstone road. The letters "U. S. P. B. M. 21" are cut into the bowlder.	320.0	329.33	344.06
At Oak Point, N. Y. The top of a roundheaded one-fourth inch brass bolt cemented into sandstone bed rock 6 inches below the surface of the ground, and 3 feet from the south fence line of the river road and 71 feet from the southeast fence corner of the intersection of the river road and the road going north into Oak Point village. The bench is N. 32° E. from intersection of center lines of said river road and said Oak Point road on the crest of the hill one-fourth mile south of Oak Point village. The bench is marked "U. S. P. B. M. 22."	322.5	325.53	340.26
At Oak Point, N. Y. The top of a roundheaded one-fourth inch brass bolt cemented into sandstone bed rock 18 inches below the surface of the ground on the west side of the road to Oak Point village, and 22 meters northwest from the intersection of the river road and the Oak Point road on the crest of the hill one-fourth mile south of Oak Point village. The bench is 30 meters west from P. B. M. 22, and 1.7 meters south from large bowlder marked "U. S. P. B. M. O. P.," with an arrow pointing to the bench. These same letters are also cut into the bed rock.	322.5	324.73	339.46
Between Oak Point and Chippewa village, N. Y. The top of a roundheaded one-fourth inch brass bolt cemented into sandstone bed rock in the valley of the Chippewa Creek S. 70° W. and 375 meters from the iron bridge over said creek. The bench is northeast from the stone residence of Alex. and Robert More, in Chippewa Valley, and 3¼ miles from Oak Point village by Chippewa road. The bench is also 25 meters south from a 30-inch white oak, blazed, and 2 meters west from a bare surface in the rock into which the letters "U. S. P. B. M. 23" are cut, with an arrow pointing to the mark. The mark is covered by about 6 inches of earth, and the same letters are cut in the rock around it.	325.5	246.33	261.06
Between Oak Point and Chippewa village, N. Y. A horizontal line cut in the center of a smooth square surface on the south face, 1.3 inches east of the southwest corner and 22 inches above the ground, of the stone dwelling house of Alex. and Robert More, in Chippewa Creek Valley, and about 2¼ miles east of Chippewa village, on the river road. The letters "U. S. 23 A." are cut into the masonry around the mark.	325.8	245.69	260.42
At Chippewa village, N. Y. The center punch mark in one-fourth inch brass bolt cemented into a corner stone on the north face of the northeast corner of schoolhouse of district No. 11, in Chippewa village, N. Y. The schoolhouse is built of sandstone masonry and is founded on bed rock. The mark is 18 inches west from the northeast corner of said schoolhouse and 38 inches above bed rock. The letters "U. S. C. V." are cut into the masonry near the bolt.	328.3	277.00	291.73

PART I—Continued.

BENCH MARKS ESTABLISHED BY PRECISE LEVELS ALONG THE ST. LAWRENCE RIVER BETWEEN HOGANSBURG, N. Y., AND CAPE VINCENT, N. Y.—Continued.

Description of location.	Distance from United States Coast Survey bench mark at Greenbush, N. Y., in miles.	Elevation above bench mark at Greenbush, N. Y.	Elevation above mean tide at New York.
At Chippewa village, N. Y The top of a roundheaded one-fourth inch brass bolt cemented into bed rock, 4.8 feet north of northwest corner of a barn on the property of Mrs. Alex. Wilson, of Brookdale, and is 130 feet west from the house on said farm. The bench is 400 meters southwest from P. B. M. C. V. and is covered by 3 inches of soil. The letters "U. S. P. B. M. 24" are cut into the bed rock.	328.6	276.63	291.36
Between Chippewa village and Alexandria Bay, N. Y The top of a roundheaded one fourth inch brass bolt cemented into bed rock, about three-fourths mile northeast from county line between Jefferson and St. Lawrence counties, N. Y., near the Callaboga road, on the property of Geo. Schermerhorn, situated about 3¼ miles above Chippewa village. The bench is at the southwest end of a stone fence forming a road fence for the property of Wm. Catlin and is about halfway between the dwellings of said Schermerhorn and Catlin. It is 11.8 feet northwest of the fence on the northwest side of the Callaboga road and 69.1 feet west from a blazed 14-inch elm tree on the south side of the road. The letters "U. S. P. B. M. 25" are cut into the bed rock and the bench is covered by 6 inches of earth.	332.9	353.44	368.17
Between Chippewa village and Alexandria Bay, N. Y The top of a roundheaded one-fourth inch brass bolt cemented into bed rock, on the property of George Springer, 111 feet south of the center line of the river road and 836 feet northeast from the intersection of the river road and the northwest and southeast road to Redwood, N. Y., which intersection is about 5¼ miles northeast from Alexandria Bay, N. Y., and three-fourths mile southwest from Springer's mill, on Crooked Creek. The bench is 238 feet southeast from a frame house on the north side of the river road and 141.7 feet south from the barn near the house. The bench is on a flat surface of the bed rock just where the surface drops off toward Cranberry Creek. The letters "U. S. P. B. M. 26" are cut into the rock.	336.8	320.04	334.77
Near Alexandria Bay, N. Y The top of a roundheaded one fourth inch brass bolt cemented into bed rock, on the property of C. M. Tamblin, 50.5 feet south of the south fence line of the river road, about 1½ miles east from Alexandria Bay. The mark is on a ledge of bed rock raised above the surrounding ground and about 300 feet east from the barn of C. M. Tamblin and 193.5 feet southeast from a small frame house on the north side of the river road. The bench is covered by 6 inches of earth, and letters "U. S. P. B. M. 27" are cut into the rock at the bench. The same letters are cut into the exposed rock adjacent to the bench, and 2 arrows cut into the rock point to the position of the bench.	340.0	259.83	274.56
At Alexandria Bay, N. Y The center punch mark in the end of a one-fourth inch brass bolt cemented into the water table or coping stone on the west side and 8 meters from the southwest corner of the stone building known as "general store" of Cornwall Bros., Alexandria Bay, N. Y. The mark is 2.3 feet above the surface of the ground and the letters "U. S. A" are cut into the masonry.	341.6	245.47	260.20
At Alexandria Bay, N. Y The center punch mark in the end of a one fourth inch brass bolt cemented into a stone on the front of the Reform Church at Alexandria Bay. The mark is 0.64 meter above the surface of the ground and 1.79 meters northwest of the east corner of the church. The letters "U. S. B." are cut into the masonry.	341.8	270.54	285.27
Between Alexandria Bay and Clayton, N. Y The top of a roundheaded one-fourth inch brass bolt cemented into bed rock. It is about 2 miles southwest of Alexandria Bay and one-fourth mile east of Geo. Clyde's residence The bench mark is 10 feet southeast of a fence which runs S. 66° E. from the east corner of a large barn on the southeast side of the road, and is 161.5 feet from the east corner of the barn, 450 feet from a cross road leading to the river, and 225 feet southeast of the southeast fence line of Clayton-Alexandri Bay road. The letters "U. S. P. B. M. 28" are cut on the bed rock	344.6	275.22	289.95

PART I—Continued.

BENCH MARKS ESTABLISHED BY PRECISE LEVELS ALONG THE ST. LAWRENCE RIVER BETWEEN HOGANSBURG, N. Y., AND CAPE VINCENT, N. Y.—Continued.

Description of location.	Distance from United States Coast Survey bench mark at Greenbush, N. Y., in miles.	Elevation above bench mark at Greenbush, N. Y.	Elevation above mean tide at New York.
Between Alexandria Bay and Clayton, N. Y. The top of a roundheaded one-fourth inch brass bolt cemented into bed rock 6 inches below the surface of the ground. In front of Mrs. Tom's residence, 2.3 feet southeast of fence; 36 feet northeast of north fence corner at the cross road to Fischer's landing; 72.6 feet from the south corner of Mrs. Tom's residence, and 131 feet northwest of the west corner of a house on the opposite side of the road. The letters "U. S. P. B. M. 29" are cut on the bed rock.	347.9	260.65	275.38
Between Alexandria Bay and Clayton, N. Y. The top of a roundheaded one fourth inch brass bolt cemented into bed rock, on the north side of road opposite the property of Fetterly, 16 feet from the fence line, 144 feet west of a culvert over a dried-up creek about 3 miles northeast of Clayton, N. Y.; 43 feet east of the southeast corner of the Fox property, 277 feet west of the northwest corner of a frame house south of the road, about one-fourth of a mile west of a schoolhouse located on the top of a ridge east of the valley. The letters "U. S. P. B. M. 30" are cut on the bed rock.	350.5	250.52	265.25
At Clayton, N. Y. The center punch mark in the end of a one-fourth inch brass bolt cemented into the corner stone of water table, 6 inches from the southwest corner and on the south side of the Catholic Church, a large stone building in Clayton, N. Y. The church is on the east side of James street, 200 feet southwest of the intersection with Mary street. The bench mark is about 6 inches east of the southwest corner of the church, and the letters "U. S. A." are cut on the water table near the mark.	353.8	265.12	279.85
At Clayton, N. Y. The center punch mark in the end of a one-fourth inch brass bolt cemented into the corner stone of the water table on the front of house, 8 inches from the northwest corner of the stone residence of E. C. Porter, on the east side of John street, between Jane and Hugunin streets, in Clayton, N. Y. The letters "U. S. B." are cut on the water table.	353.5	250.68	265.41
At Clayton, N. Y. The center punch mark in the end of a one-fourth inch brass bolt cemented into the stone of masonry wall on the west side of the stone residence of Hall B. Dewey, in Clayton, N. Y., at the southwest corner of Hugunin and Merrick streets, and one block south of the St. Lawrence River, also one block southwest of the N. Y. C. & H. R. R. R. station. The bench mark is 3.5 feet from the northwest corner of the building and 2.3 feet above the surface of the ground. The letters "U. S. C." are cut on the masonry.	353.5	246.93	261.66
Between Clayton and Cape Vincent, N. Y. The top of a round-headed one-fourth inch brass bolt cemented into a large sandstone bowlder, which is set firmly in the ground and which is 5 feet in diameter at the surface of the ground; 52 feet south of an angle in the road about 3 miles southwest of Clayton, N. Y. It is on the timber line, at the southwest end of a clearing and about 500 feet southeast of a log cabin 3.5 feet north of a spike driven in a blaze (facing the bench mark) on a 14-inch oak tree. The letters "U. S. P. B. M. 31" are cut on the bowlder.	355.8	250.98	265.71
Between Clayton and Cape Vincent, N. Y. The top of a round-headed one-fourth inch brass bolt cemented into bed rock, 1 meter west of the vertical ledge of rock along a creek and 46.3 meters S. 25° E. from the center of an arch bridge over the creek, about 6 miles southwest of Clayton, N. Y.; 10.3 meters S. 20° W. from a 14-inch elm tree east of the creek and 11 meters N. 20° W. from an 18-inch elm west of the creek. The letters "U. S. P. B. M. 32" and two arrows pointing toward the bench mark are cut on the bed rock.	358.7	259.17	273.90

PART I—Continued.

BENCH MARKS ESTABLISHED BY PRECISE LEVELS ALONG THE ST. LAWRENCE RIVER BETWEEN HOGANSBURG, N. Y., AND CAPE VINCENT, N. Y.—Continued.

Description of location.	Distance from United States Coast Survey bench mark at Greenbush, N. Y., in miles.	Elevation above bench mark at Greenbush, N. Y.	Elevation above mean tide at New York.
Between Clayton and Cape Vincent, N. Y. The top of a round-headed one-fourth inch brass bolt cemented into bed rock about 800 feet east of the west end of Dodges Bay, on the north side of the road; 22 feet from the ledge of rock at the shore, 80.4 feet west of a 10-inch ash tree, 64.3 feet north from a nail driven in a blaze, facing the mark, on a maple tree situated on the fence line south of the road; 66.3 feet north of the intersection of fence along south side of road with a division-line fence to the south. The letters "U. S. P. B. M. 33" and arrows pointing to the mark are cut on the bed rock, which is covered slightly with earth and sod.	361.6	246.10	260.83
Between Clayton and Cape Vincent, N. Y. The top of a round-headed one-fourth inch brass bolt, cemented into bed rock in a pasture north of road; 520 feet N. 57° E. from a large bowlder on the north of fence line, which bowlder is 215 feet west of 10-foot plank bridge over a dried-up creek and 344 feet west of a crossroad leading south to a frame house at the foot of a hill in Hester Woods, 3.5 miles below Cape Vincent, N. Y. The bench mark is 37 feet east from a spike on the blaze of a 12 inch elm tree. The letters "U. S. P. B. M. 34" are cut on the bed rock.	364.9	246.60	261.33
At Cape Vincent, N. Y. The center-punch mark in the end of a one-fourth inch brass rod cemented in the corner stone at the southwest corner of the United States Fish Hatchery (a stone building) at Cape Vincent, N. Y. The mark is on the east side of the building, 0.38 meter from the corner and 1.04 meters above the surface of the ground. The letters "U. S. A." are cut into the stone.	368.3	240.45	255.18
At Cape Vincent, N. Y. On a 1 inch square smooth, level surface cut on the top of water table 12 inches south of the northwest corner of the Jerome House, a brick hotel, situated at the northeast corner of a street intersection two blocks south of the Cleveland Seed Co.'s dock and warehouse at Cape Vincent, N. Y. The stone of the water table has cut on it the letters "U. S. B."	368.6	245.78	260.51
At Cape Vincent, N. Y. The center-punch mark in the end of a one-fourth inch brass rod cemented in the corner stone, 39 inches west of the northeast corner of tower of Catholic Church, a large stone building in Cape Vincent, N. Y. The letters "U. S. C." are cut on the corner stone.	368.7	258.47	273.20
At Tibbets Point, near Cape Vincent, N. Y. The center-punch mark in the end of a one-fourth inch brass rod cemented in foundation stone on the north side of Tibbets Point Light-House tower on Tibbets Point, on the shore of Lake Ontario. The mark is 6 inches above the surface of the ground, and the letters "U. S. P. B. M. 35" are cut on the foundation stone.	371.1	250.16	264.89

PART II.—*Bench marks between Lake Erie and Lake Ontario.*

LINE FROM BUFFALO TO OLCOTT, VIA TONAWANDA AND LOCKPORT.

Location.	Distance in miles from Buffalo bench mark.	Elevation above bench mark, Buffalo, N. Y.	Elevation above mean tide, New York.
Buffalo Light-House Bench mark is located on east corner of most northerly Buffalo light-house, at the east angle and on the upper surface of the plinth of the light-house south United States pier.	....	....	589.81
International Bridge, Buffalo Bench mark is the highest point of square cut on projecting ledge of third stone from south end, fifth course below bridge seat of east abutment of International Bridge over Erie Canal.	4.3	−10.20	579.61
Black Rock, Guard Lock Bench mark is square cut in coping of lock masonry on towpath side opposite hollow quoin of upper gate.	4.7	−13.57	576.24
Between Buffalo and Tonawanda Bench mark is on the second stone below the coping of the south end of the west abutment of Cherry's bridge. It is a square cut on a stone projecting back of the abutment.	9.9	−13.66	576.15
Tonawanda Bench mark is a square cut on stone water table on west side of steeple of red-brick church at the southeast corner of Broad and Seymour streets (Christian Chapel).	12.3	−13.77	576.04
Tonawanda Bench mark is a square cut on the northeast surface stone of the south abutment of the Tonawanda Dam, between bolted iron bars.	12.7	−14.83	574.98
North Tonawanda Bench mark is a half-square cut on top stone step of east entrance to Ascension Church, corner Vandevoort and Robinson streets, at west corner doorsill.	13.5	−10.21	579.60
North Tonawanda Bench mark is a square cut on the cut-stone water table at the left of the entrance to the old engine house (1873) of the Tonawanda Iron and Steel Co.	13.7	−11.17	578.64
Sawyers Creek Bench mark is a square cut on stone water table at southwest corner of barrel-organ factory.	16.4	−8.48	581.33
Pendleton Center Bench mark is a square cut on top of bowlder, about 3 feet in diameter, of light-colored gneiss or granite. The bowlder is on east side of highway, and about 400 feet north of Erie R. R. station.	21.6	+1.22	591.03
Pendleton Center Bench mark is a square cut on the corner of stone water table at the west corner of brick house owned by H. S. Taylor. Building is east of the church.	22.5	+31.06	620.87
Lockport Bench mark is a square cut on projection of stone at angle of abutment and wing wall, lower course, south angle of west abutment of the more westerly of the two subways under the N. Y. C. R. R., at head of gulf, about 1 mile west of Lockport.	26.0	+0.44	590.25
Lockport Bench mark is a square cut on north corner of water table of two-story red-brick dwelling occupied by Mr. Pickles. Building is on the stone road about 2¼ miles northwest of Lockport.	28.2	−189.38	400.43
Schoolhouse No. 13, town of Lockport Bench mark is a square cut on west end of stone doorstep of red-brick schoolhouse. Building is at intersection of turnpike and Ewing road.	31.1	−217.79	372.02
Wrights Corners post-office Bench mark is square cut on stone water table on two-story brick residence occupied by Mr. Boist, at northeast corner of house House is about 300 feet north of intersection of Lake avenue and turnpike road.	32.9	−185.49	404.32
Cemetery United States Geological Survey Bench mark is loop of capital P, on lot monument, Pettit lot, southeast corner. Cemetery is on east side of Lake avenue, 1½ miles south of village of Newfane. (See report of New York State engineer, 1886, page 152.) Elevation 355.60+1.085, difference in datum, =356.69.	35.7	−232.93	356.88
Newfane Bench mark is a square cut on cut-stone bridge seat of iron highway bridge on crossroad over Eighteen Mile Creek in northern portion of village. Square is at north end of east abutment.	33.9	−284.63	305.18
Schoolhouse No. 10, town of Newfane Bench mark is square cut on southwest corner of stone water table of brick schoolhouse on west creek road, about 2,700 feet north of Newfane station.	35.7	−259.54	330.27

PART II.—*Bench marks between Lake Erie and Lake Ontario*—Continued.

LINE FROM BUFFALO TO OLCOTT, VIA TONAWANDA AND LOCKPORT—Continued.

Location.	Distance in miles from Buffalo bench mark.	Elevation above bench mark, Buffalo, N. Y.	Elevation above mean tide, New York.
Olcott Bench mark is square cut on stone water table at southwest corner of one-story school house, district No. 11, town of Newfane	37.7	−303.47	286.34
Olcott Bench mark is square cut on stone water table at southwest corner of two-story red-brick building occupied as a general store by C. D. Shaw. Building is on north side of street and about 700 feet west of creek.	37.7	−330.54	259.27
Olcott Bench mark is a square cut on south end of stone doorsill of front entrance to First Universalist Church, a red-brick building erected in 1858.	38.0	−302.45	287.360

BENCH MARKS ON CANADIAN SIDE OF NIAGARA RIVER, FROM INTERNATIONAL BRIDGE TO FOOT OF LAKE ERIE.

[NOTE.—The elevations given in these lists depend on the elevation of 589.807 above mean tide at New York of the bench mark on light-house at Buffalo, determined from the United States Lake Survey.]

International Bridge Bench mark is a square cut on projecting face of stone of fourth course below bridge seat of east or American abutment of main bridge over Niagara River. It is on the north face of stone at the northwest corner of abutment	4.6	−7.79	582.02
International Bridge Bench mark is a square cut on projecting face of stone of fifth course below bridge seat at northeast corner of west or Canadian abutment.	4.7	−10.00	579.21
Fort Erie Bench mark is the head of a spike driven in bench cut on root of cottonwood tree. The tree is about 220 feet north of the Fort Erie Ferry landing and about 10 feet east of the M. C. R. R. tracks.	6.0	−19.48	570.33
Lake Erie Bench mark is the head of a spike driven in bench cut on north tree of row of six willows just south of group of five willows in front of Constable Metcalf's house at the head of Niagara River on Canadian side.	7.8	−7.92	581.89

BENCH MARKS FROM NORTH TONAWANDA TO NIAGARA FALLS.

Crossing of B. & N. F. E. R. R. over N. Y. C. & Erie R. Rs Bench mark is the top of 1-inch anchor bolt (marked "X" with chisel) in the north foundation of the first iron trestle bent west of the east abutment. Bolt is the northeast bolt of four in foundation.	15.8	−17.47	572.34
Town of Wheatfield, District No. 2 Bench mark is a square cut on south end of stone water table on east front of brick schoolhouse.	16.0	−13.45	576.36
Lasalle Bench mark is the summit of a square cut on northwest corner of bridge seat of east abutment of N. Y. C. R. R. bridge over Cayuga Creek just south of the Lasalle station.	18.4	−18.39	571.42
Town of Niagara, District No. 5 Bench mark is the summit of a square cut on the southwest corner of stone water table on brick schoolhouse.	19.4	−14.75	575.06
Echota Bench mark is a square cut on cut stone doorsill of west door of south face of N. Y. C. R. R. station. Mark is at west end of sill.	21.4	−17.12	572.69
Niagara Falls Power Co Bench mark is a small square cut on northwest corner of square stone 5.5 inches square set in concrete about 10 feet west of entrance to main power house. It is in gutter at front of building and a reference stone for tunnel center line. There is a lead plug in top.	22.6	−23.47	566.34
Niagara Falls Power Co.'s bench Bench mark is the top of a spike in wood set down in pit with brick walls at foot of elm tree 5 feet in diameter. Tree is just outside of curb on Buffalo avenue and 800 feet west of entrance to power house. Pit is covered with flat stone 15 inches square, with iron ring in top.	22.8	−23.00	566.81

PART II.—*Bench marks between Lake Erie and Lake Ontario*—Continued.

BENCH MARKS FROM LASALLE TO LEWISTON.

[See page 1015.]

Location.	Distance in miles from Buffalo bench mark.	Elevation above bench mark, Buffalo, N. Y.	Elevation above mean tide, New York.
Lockport Branch N. Y. C. R. R .... Bench mark is a square cut at northwest corner of cut-stone monument between tracks. Monument is numbered 16 and is at a point about 600 feet west of military road, where Cataract Construction Co.'s line branches to southwest.	21.8	+16.35	606.16
Lewiston .... Bench mark is the summit of a square cut on flat rock approximately 30 feet from north pillar of Penjerrick gateway. Gateway is on military road about 200 feet south of junction with river road, just south of the escarpment.	25.5	+10.93	600.74
Lewiston .... Bench mark is a square cut on northwest corner of doorsill of north door of west wing of seminary building, Center and Ninth streets.	26.5	−188.60	401.21
Lewiston .... Bench mark is a square cut on water table northeast corner of foundation of brick store owned by Eugene Murphy. Building is on lot No. 252, on south side of Center street between Fourth and Fifth streets.	26.5	−226.59	363.22
Lewiston .... Head of spike driven in bench cut on root of white-oak tree 12 inches diameter. Tree is just west of river road, 1.3 miles north of Lewiston and about 1,600 feet north of the residence of F. Hays.	27.7	−264.64	325.17
Lewiston .... Bench mark is a square cut on top of west wing of north abutment of trestle No. 2, on Gorge route over Fish Creek, about 5,600 feet south of N. Y. C. R. R. station. The square is on the southeast corner of fifth stone from west end of wing.	28.5	−305.25	284.56

PART III.—*Bench marks established by precise levels along the Detroit River, Lake St. Clair, and the St. Clair River between Gibraltar and Port Huron, Mich.*

Description.	Distance in miles from bench mark at Gibraltar, Mich.	Elevation in feet above the bench mark at Gibraltar, Mich.	Elevation in feet above mean tide at New York.
At Gibraltar, Mich .... The center of small hole in the head of a copper bolt, leaded horizontally, in the foundation wall of light house tower (now abandoned and used as a dwelling) at its southeast corner, east face, and in the fourth course of masonry below the cut sandstone water table. This corresponds to the United States bench mark "Gibraltar" of 1877; elevation, 582.45.	....	....	582.45
At Gibraltar, Mich .... On the same light-house as above (now used as a dwelling house). On the southeast corner of the stone doorsill of the door in the southeast angle of the building; being marked by a right angle cut on the stone. This corresponds to bench mark 2 of 1875; elevation, 584.97.	....	2.51	584.96
At Gibraltar, Mich .... In the south part of the town, on lake front, in the rear of Mr. Edward Hall's dock and boathouse, 75 feet southwest of his house, in the northeast corner of stone milk house, in east face 8 inches south from corner, and 4 feet 4 inches above ground; being center mark of brass bolt, leaded horizontally.	0.2	5.08	587.53
At Trenton, Mich .... On the southeast corner of Washington avenue and St. Joseph street, in the northwest corner of "Commercial Hotel," in west face, second stone from corner, and in first course below water table; being center of small hole in copper bolt, leaded horizontally. This corresponds to United States bench mark "Trenton" of 1877; elevation, 603.42.	4.0	20.97	603.42

Part III.—*Bench marks established by precise levels along the Detroit River, Lake St. Clair, and the St. Clair River between Gibraltar and Port Huron, Mich.*—Continued.

Description.	Distance in miles from bench mark at Gibraltar, Mich.	Elevation in feet above the bench mark at Gibraltar, Mich.	Elevation in feet above mean tide at New York.
At Trenton, Mich. On the northwest corner of St. Joseph street and Washington avenue, in stone base of store building belonging to Joseph Anderson, 5 feet 4 inches north of north side of door and 4½ inches south of north pillar and 4 inches back from face, being top of brass bolt, leaded vertically, and marked "U. S. P. B. M."	4.0	19.18	601.63
Between Trenton and Wyandotte, Mich. The bench mark is 2,525 feet above Sibley's stone quarry (crushing plant), on the north side of Mud street and 354 feet west of center of South road, in foundation of F. B. Sibley's residence, in first course below base board and 1.5 feet above ground, 18.9 feet south of the northeast corner, being center of punch mark in brass bolt, leaded horizontally, and marked U. S. □ P. B. M.	6.1	10.93	593.38
At Wyandotte, Mich. On the west side of Biddle avenue, 171 feet south of south side of Oak street, in south pedestal stone of south pillar of brick store, used as meat market, owned by J. P. Debo. It is 8½ inches east of face of building and 4½ inches north of north face of pillar, being top of brass bolt, leaded vertically, and marked U. S. P. B. M.	8.8	3.21	585.66
At Wyandotte, Mich. It is 2,700 feet west of Biddle avenue, on south side of Oak street, in Union School building, on north side of foundation, in third course of masonry below the water table inclosed by fire escape wire screen, being center of small hole in head of copper bolt, leaded horizontally, and marked U. S. P. B. M. This corresponds to United States bench mark "Wyandotte" of 1877; elevation, 586.27.	9.3	3.86	586.31
At Ecorse, Mich. On the east side of river road, at the foot of Labadie street, on Mr. W. D. Smith's residence, in the east face of foundation, 10½ inches from the southeast corner, in the seventh course of brick below the base board, being center mark of brass bolt, leaded horizontally.	11.5	2.25	584.70
At Ecorse, Mich. Opposite the head of Fighting Island, at the Tecumseh Salt Works, 136 feet east of the northeast corner of boiler room, on river front at the end of railroad track, 11 feet west of the bumper and 4½ feet north of north rail, on top of pile 10 inches in diameter and 14 inches above ground, being top of 20d wire spike driven to surface and circumscribed by a 2-inch square cut into the wood by a cold chisel.	12.6	—3.85	578.60
At Delray, Mich. At the northeast corner of River and Louis streets, on the west side of first entrance east from Louis street, on the southwest corner of pedestal stone of west pillar of doorway, being the corner of stone marked by two lines cut at right angles with each other and forming a square.	15.8	10.79	593.24
At Detroit, Mich. In the southwest quarter of the Fort Wayne grounds, on the river front of building No. 60, officers' quarters, in the center of water-table course, 20 inches east from vertical center line of front of building, and 3 feet 5 inches above the ground, being center of brass bolt, leaded horizontally, and marked U. S. P. B. M.	16.2	18.98	601.43
At Detroit, Mich. On the south side of Atwater street east, one block and a half east of Woodward avenue, on the office building of the city electric lighting plant, on the west end of doorstone of front entrance, 5 inches east of west face and 4 inches north of south face, being top of brass bolt, leaded vertically, and marked U. S. □ P. B. M.	20.0	.49	582.94
At Detroit, Mich. On the foundation of the light-house depot, 8.2 feet below outer edge of the water table, on the west door jamb of south door; being center of cross cut in the stone. This corresponds to United States bench mark "Detroit," 1871; elevation, 584.78	21.7	2.29	584.74

PART III.—*Bench marks established by precise levels along the Detroit River, Lake St. Clair, and the St. Clair River between Gibraltar and Port Huron, Mich.*—Continued.

Description.	Distance in miles from bench mark at Gibraltar, Mich.	Elevation in feet above the bench mark at Gibraltar, Mich.	Elevation in feet above mean tide at New York.
At Detroit, Mich At the northeast corner of Wight street and Mount Elliott, on the north end of doorstep of west entrance to Ireland & Matthews Manufacturing Co., 5 inches from north end of step, and 3¼ inches from front edge of stone; being top of brass bolt, leaded vertically, marked "U. S. ☐ P. B. M."	21.9	10.28	592.73
At Detroit, Mich At the Detroit Waterworks, on standpipe tower, on side facing the river, on southwest end of doorstone of entrance to tower, 5 inches northeast from vertical face and 4 inches from edge of stone; being top of brass bolt, leaded vertically, and marked "U. S. ☐ P. B. M."	23.7	5.04	587.49
Near Detroit, Mich At Windmill Point light-house station, on the southwest corner of keeper's house, 2 feet 5 inches east from sloping corner, in third course of masonry below water table, and 3¼ feet above ground; being center mark in brass bolt, leaded horizontally, and marked "U. S. ☐ P. B. M."	26.3	1.70	584.15
Near Detroit, Mich At Windmill Point, in the foundation of light-house tower, in its north by east face, in fifth course of the masonry below the cut stone water table; being a horizontal groove cut in stone slab, 2¼ by 1¼ inches, on face set in flush with masonry, and known as old bench mark "W."	26.3	.24	582.69
Near Grosse Point, Mich At "Cottage Grove Post-Office" on the southwest corner of Chas. Seitz's house, 7¼ feet west of corner, and 4¼ inches below west end of stone window sill, and 2 feet 2¼ inches above stonework of foundation, in second course of brickwork below window sill; being center of brass bolt and leaded horizontally.	27.8	9.56	502.01
At New Baltimore, Mich In the southwestern part, on the lake front, on the northwest side of Main street, in the front face of foundation of house owned by heirs of Edward Rose, 7 inches west of cellar window, and 5 inches below water table; being center mark of brass bolt, leaded horizontally, and marked "U. S. P. B. M."	56.0	7.74	590.19
At New Baltimore, Mich At the southwest corner of Main and Washington streets, on the corner building owned by William Baker, north side, in the window base of west window, 9 inches east of west end of stone, and 4 inches from its front edge; being top of brass bolt, leaded vertically, and marked "U. S. P. B. M."	56.4	6.09	588.51
At New Baltimore, Mich About 1,900 feet above Washington street, on east side of Main street, at the northwest corner of Henry C. Schnoor's residence, in water table, 6 inches east of its west end; being center mark of brass bolt, leaded horizontally, and marked "U. S. P. B. M."	56.7	17.56	600.01
Between Swan Creek and Fair Haven, Mich About 1 mile west of Fair Haven, and about a half mile east of Swan Creek, at the southwest corner of Mrs. C. Rose's house, south face; in the foundation, fourth course above ground, second course below water table; being center mark of brass bolt, leaded horizontally, and marked "U. S. P. B. M."	61.2	1.29	583.74
At Fair Haven, Mich At Henry C. Schnoor's stave mill, on the lake front, in the south face of brick chimney near the boiler-room door, in the tenth brick east from west face, and in the twenty-second course of brick above the ground; being center mark of brass bolt, leaded horizontally.	62.1	.98	583.43

Part III.—*Bench marks established by precise levels along the Detroit River, Lake St. Clair, and the St. Clair River between Gibraltar and Port Huron, Mich.*—Continued.

Description.	Distance in miles from bench mark at Gibraltar, Mich.	Elevation in feet above the bench mark at Gibraltar, Mich.	Elevation in feet above mean tide at New York.
At Algonac, Mich In the foundation of public school, at the northeast corner of east wing, in north face of corner stone; being center mark of brass bolt, leaded horizontally, and marked $\overset{\text{U.S.}}{\text{P.B.M.}}$	68.6	2.39	584.84
At Algonac, Mich In the foundation of the town hall, on its east face, sixth brick south from the northeast corner, and in the eighth course of brick above stone foundation; being center mark of brass bolt, leaded horizontally.	68.7	2.64	585.0[illegible]
Near Roberts Landing, Mich About one-half mile north of Roberts Landing, on the river front, on the house owned by D. B. Shier and A. S. Freeman, on the north face in the corner brick at the northwest corner of kitchen, in the sixteenth course above ground; being center mark in brass bolt, leaded horizontally.	72.7	2.69	585.14
At Marine City, Mich On the southeast corner of Water and Union streets, in the Marine City Stave Co.'s store, near northwest corner, on stone base under window, 8 inches south of north end and 2½ inches from front edge; being top of brass bolt, leaded horizontally, and marked $\overset{\text{U.S.}}{\text{P.B.M.}}$	75.9	3.95	586.40
At Marine City, Mich On the northwest corner of Main and Broad streets, on the city hall, near its southeast corner, at the window entrance to corridor, 2 feet 5 inches above the ground, 5 inches south of the north jam; being the top of a brass bolt, leaded vertically, and marked $\overset{\text{U.S.}}{\text{P.B.M.}}$	76.3	5.65	588.10
At Marine City, Mich In the upper part of the city, at the city waterworks building, on west face, 5 inches north from the southwest corner, and 2½ feet above ground; being center mark of brass bolt, leaded horizontally.	76.6	7.34	589.79
At East China, Mich A half mile above Ricord's dock, on river front, in foundation of Rankin's house, south side, between kitchen and cellar doors, 28 inches east of east kitchen door jam, 7½ inches below weather board and 18 inches above ground; being center mark of brass bolt, leaded horizontally, and marked $\overset{\text{U.S.}}{\text{P.B.M.}}$	79.7	8.34	590.79
At St. Clair, Mich In the lower part of the town, on river front, at John Schlinkert's coal yard, in brick wall of "old storehouse," 7½ inches north from the southeast corner and 4.1 feet above ground, and in the twenty-first course of brick below woodwork of gable; being center mark in brass bolt, leaded horizontally.	83.6	17.17	599.62
At St. Clair, Mich At the city waterworks, 5 feet 7½ inches south of south end of door stone at main entrance, in water table; being top of brass bolt, leaded vertically, and marked $\overset{\text{U.S.}}{\text{P.B.M.}}$	84.1	6.30	588.75
At St. Clair, Mich On the top of north hill, on west side of Front street, in foundation of Mr. Mark Hopkins's residence, in the east face, in second stone south of the northeast corner, top course of masonry; being center mark in brass bolt, leaded horizontally, marked $\overset{\text{U.S.}}{\text{P.B.M.}}$	84.4	44.79	627.24
At Marysville, Mich Diagonally opposite Marysville Hotel, in foundation of N. B. Mills's store, in second brick east from west corner and in seventh course above stone foundation; being center mark in brass bolt, leaded horizontally.	89.7	7.51	589.96
At Marysville, Mich At the upper mill (Sanburn sawmill), on chimney bearing stone marked "1871," in west end of south face in corner brick, seventeenth course above the stone foundation; being center mark in brass bolt, leaded horizontally.	89.9	4.66	587.11

PART III.—*Bench marks established by precise levels along the Detroit River, Lake St. Clair, and the St. Clair River between Gibraltar and Port Huron, Mich.*—Continued.

Description.	Distance in miles from bench mark at Gibraltar, Mich.	Elevation in feet above the bench mark at Gibraltar, Mich.	Elevation in feet above mean tide at New York.
Near Port Huron, Mich About 2 miles below Black River, Port Huron, on river, at Alverson & Dunford's dry dock, in south face of the boiler house of pumping station, in top course of stone foundation, 10 inches west from west face of coal door and 6 inches below top of stone; being center mark of brass bolt, leaded horizontally, and marked $\overset{\text{U. S.}}{\text{P. B. M.}}$	93.3	14.22	596.67
At Port Huron, Mich It is 290 feet south of Black River, on west side of Military street, on the opera house block, at center post of front entrance, on the extreme southeast corner of iron plate; being surface inside of square 1 inch on a side.	95.4	12.76	595.21
At Port Huron, Mich On the court-house, on the stone door step of the northeast basement door, 4¼ inches south of south jam and 3¼ inches from front edge; being top of brass bolt, leaded vertically, and marked $\overset{\text{U. S.}}{\text{P, B. M.}}$	95.8	16.92	599.37
At Port Huron, Mich At the city waterworks, at the south end of coal shed, 66 feet south of south face of main building, on coping stone of the south retaining wall, 6 inches from its south face and 6 inches from its east end, at which point of wall of south end of coal shed rises vertically 3 feet to upper coping; being top of brass bolt, leaded vertically, and marked $\overset{\text{U. S.}}{\text{P. B. M.}}$	96.4	17.64	600.09
At Port Huron, Mich At the foot of Lake Huron, 2¼ miles above the Black River, Port Huron, at Fort Gratiot light-house, in south foundation wall of brick dwelling at light-house, in upper course of masonry, 2.1 feet from southeast corner and 0.6 foot below the water table; being center of small hole in head of copper bolt, leaded horizontally. This corresponds to U. S. B. M., "Fort Gratiot," 1877 elevation 589.90.	97.8	7.84	590.29

APPENDIX No. 23.

REPORT OF THE SECRETARY OF THE BOARD.

U. S. BOARD OF ENGINEERS ON DEEP WATERWAYS,
OFFICE OF THE SECRETARY,
Detroit, Mich., June 30, 1900.

GENTLEMEN: As secretary and disbursing officer of the Board, I have the honor to file the following report:

August 10, 1897, the Secretary of War, by direction of the President, commissioned me as secretary of the Board, to date from August 7, 1897, and I was directed to report to Major Raymond, Corps of Engineers, U. S. Army, at Philadelphia, which I did on August 12, when the Board met and organized.

On October 22, 1897, I filed with the War Department surety bond No. 219184 of the American Surety Company, New York, dated August 18, 1897, in my favor, for $25,000, having been designated as disbursing officer to disburse the appropriation.

This bond was for one year, and was approved. It has been renewed from time to time and is still in force. It has cost me $308.33 for premiums thereon. Previous to the filing of my bond Major Raymond had acted as disbursing officer.

The assistant treasurer of the United States, New York, was designated as depositary of funds belonging to the various appropriations made by acts of Congress for the work of the Board, though a small deposit was kept with the Commercial National Bank, Detroit, United States depository, for convenience in making local payments. The total deposits have been:

With assistant treasurer, United States, New York	$365,000.00
With Commercial National Bank, Detroit	119,908.64
Total	484,908.64

All bills have been paid by check upon vouchers, the checks in all cases being drawn to the order of the person, firm, company, or corporation to whom the payment was due. Under no circumstances has a dollar of the appropriations been drawn out in any other way. In order that incidental expenses of field parties might be adjusted with promptness and the vigorous prosecution of the work not hindered by delay in making payments of board bills, traveling expenses, etc., while awaiting the preparation of proper vouchers, money has at various times been advanced to the chiefs of parties by Mr. Noble and Mr. Wisner, members of the Board and by the chiefs of parties themselves. This has necessitated recourse to the expedient of reimbursement vouchers. The plan worked well, and work has never been permitted to lag for an instant for lack of funds. These gentlemen are entitled to the thanks of the Government for willingness to draw upon their private resources in order to expedite the work, and the disbursing officer hereby expresses his appreciation of the cheerful acquiescence with which they met his wish to avoid the handling of Government money and to make no payments except by check upon vouchers duly and properly executed.

At the outset, with many field parties scattered over a wide area, it was often difficult to get the vouchers promptly and in correct form to meet all the requirements of the Treasury, and but for the generous action of members of the Board and chiefs of parties it would have been necessary at times to draw out considerable sums and intrust the same to many different employees in anticipation of payments that had to be made in cash on the spot and before vouchers could be procured. By advancing their own money and the employment of reimbursement vouchers, with receipts attached as subvouchers, all delay was avoided, and the field work was pushed at all points with remarkable celerity and success. Chiefs of parties were not all trained accountants, and the most carefully prepared detailed instructions from this office did not entirely eliminate errors, and it was sometimes necessary to return vouchers several times for correction before checks could be drawn. Every assistance possible was afforded by the force of clerks in the secretary's office, and chiefs of parties were not permitted to be hampered in their field surveys and investigations by the supervision of unnecessary clerical work. The Board at one time had twelve parties in the field and in its employ about 400 men, and the monthly expenditures amounted to as much as $35,000.

It was the practice of this office to pay all vouchers sent in from the field within twenty-four hours of their receipt, except in cases where they were in some respect faulty, when they were returned immediately with instructions how to make the necessary alterations or emendations, and it was rare that more than a week was consumed in getting them back ready for payment. It is believed that the promptness and accuracy with which disbursements have been made by this office have given the utmost satisfaction to all concerned. Only once—in the summer of 1898, when the Board was organizing a number of new field parties—was the rule of having the office crowd the work departed from. Vouchers accumulated with such rapidity that the clerical force could not handle them, and for a week or two the work crowded the office. The sudden death of Mr. Richard Common, chief clerk, added to the embarrassment. But the tangle was soon unraveled, and did not occur again.

Secretary Alger in the orders of October 20, 1897, for the government of the Board, allowed it considerable latitude in the matter of making purchases, and directed that all reports be made directly to him. He also relieved the Board from the operations of the civil-service act in the selection of their subordinates. This confidence was highly appreciated and never abused, and it worked greatly to the advantage of the Government, so far as this particular work was concerned. Purchases were made in open market whenever that method was the most expeditious and economical. Bids were asked for when there was time and the delay would not interfere with vigorous prosecution of the work.

In the selection of employees care was exercised to choose men with reference solely to their especial fitness for the work they were required to do, and it may be said without fear of contradiction that no more capable and efficient corps of subordinates was ever assembled than that one which has had charge of the various departments under this Board. This remark applies not only to the chiefs of parties, but to the men who made up those parties; to the field work not only, but to the drafting and computing department and to the secretary's office as well. The Board has been absolutely nonpartisan. No man was asked as to his politics or his political backing. Fitness was the only test applied.

Following is a statement of receipts and expenditures during the life of the Board, to and including June 30, 1900:

RECEIPTS.

Appropriation act approved—	
June 4, 1897	$150,000.00
July 1, 1898	225,000.00
March 3, 1899	90,000.00
February 9, 1900	20,000.00
Miscellaneous receipts	712.96
	485,712.96

EXPENDITURES.

For surveys and examinations of waterways	$210,795.13
For borings	96,034.22
For expenses and salaries of Board	42,117.73
For water-supply investigation, Oswego-Mohawk route	41,576.29
For expenses and salaries, drafting and computing department	31,392.13
For expenses and salaries, secretary's office	26,692.12
For statistical inquiry	8,998.39
For discharge measurements Niagara River	8,872.48
For diamond-drill borings	7,800.56
For St. Lawrence River levels	3,732.59
For precise levels, Detroit and St. Clair rivers	1,824.92
For discharge measurements, St. Lawrence River	1,459.34
Disbursed by Colonel Raymond	98.96
For proceeds sale condemned property deposited United States Treasury	73.55
Disbursed by Treasury Department	2.65
Balance on hand	4,241.90
	485,712.96

BALANCE ON HAND—WHERE DEPOSITED.

The balance remaining on hand is deposited as follows:

With the assistant treasurer United States, New York	$1,359.05
With the Commercial National Bank, Detroit	2,882.85
	4,241.90

MISCELLANEOUS RECEIPTS—WHENCE DERIVED.

The item of "Miscellaneous receipts" is accounted for thus:

January 5, 1900, proceeds sale 3 transits	$300.00
August 26, 1899, check given for services, returned and canceled	250.00
October 14, 1899, sale of condemned property	73.55
October 16, 1899, disallowances traveling expenses, amount refunded	32.41
April 19, 1899, received from employee to repair transit	20.75
January 29, 1900, overpayment refunded	12.50
March 31, 1898, disallowances traveling expenses, amount refunded	10.25
October 22, 1898, disallowances traveling expenses, amount refunded	8.50
June 4, 1898, disallowances notary fees, amount refunded	5.00
	712.96

ANALYSIS OF EXPENDITURES.

An analysis of the comparative cost of the various branches of the work gives the following results:

The Lasalle-Lewiston route, cost of—		
For borings	$1,601.22	
For surveys	4,598.92	
		$6,200.14
The surveys of Niagara River, cost of—		
For borings	4,738.08	
For surveys	6,912.38	
		11,650.46
The Tonawanda-Olcott route, cost of—		
For borings	4,981.43	
For surveys	12,450.38	
		17,431.81
The surveys of the Hudson River, cost of—		
For borings	7,272.40	
For surveys	11,984.70	
		19,257.10
The Champlain route, northern division, cost of—		
For borings	8,581.60	
For surveys	21,835.56	
		30,417.16
The Champlain route, Hudson River division, cost of—		
For borings	7,171.25	
For surveys	26,743.70	
		33,914.95
The Oswego-Mohawk route, eastern division, cost of—		
For borings	30,057.29	
For surveys	52,658.38	
		82,715.67
The Oswego-Mohawk route, western division, cost of—		
For borings	23,812.08	
For surveys	61,505.90	
		85,317.98
Discharge measurements, St. Lawrence River		1,459.34
Precise levels, Detroit and St. Clair rivers		1,824.92
Precise levels of the St. Lawrence River, cost of, for all purposes		3,732.59
The diamond drill borings, cost of, for all purposes		7,800.56
Water-supply investigation		41,576.29
Surveys of the St. Lawrence River		19,924.08
Discharge measurements, Niagara River		8,872.48
Statistical inquiry, cost of, for all purposes		8,998.39
Salaries and expenses of secretary's office		26,692.12
Salaries and expenses of drafting and computing department		31,392.13
Salaries and expenses of board		42,117.73
Miscellaneous expenditures		175.16
Balance on hand		4,241.90
Total		485,712.96

EXPENDITURES BY FISCAL YEARS.

Receipts:		
Total receipts from all sources		$485,712.96
Disbursements:		
For fiscal year ending June 30—		
1898	$118,774.14	
1899	301,478.46	
1900	61,043.30	
Miscellaneous	175.16	
Balance on hand	4,241.90	
		485,712.96

The following table gives the total square and linear miles surveyed and average cost per square mile for the different divisions:

Total square and linear miles surveyed and average cost per mile for different divisions.

	Lake Erie to Lake Ontario.			Champlain route.		
	Lasalle-Lewiston route.	Tonawanda-Olcott route.	Niagara River.	St. Lawrence River.	Northern division.	Hudson River division.
Topography in square miles	7.55	33.00	2.00	15.25	67.25	57.50
Hydrography in square miles	....	88	20.25	13.75	3.25	10.82
Total area in square miles	7.55	33.88	22.25	29.0	70.50	68.32
Total cost of surveys	$4,598.92	$12,450.88	$6,912.38	$12,105.21	$21,835.56	$26,743.70
Average cost of surveys per square mile	$609.13	$367.48	$310.67	$417.42	$309.72	$391.45
Total cost of borings	$1,601.22	$4,981.43	$4,738.08	$7,818.87	$8,581.60	$7,171.25
Average cost of borings per square mile	$212.08	$147.03	$212.94	$269.61	$121.72	$104.97
Total cost of surveys and borings, including office reduction and estimate of cost	$6,200.14	$17,431.81	$11,650.46	$19,924.08	$30,417.16	$33,914.95
Total average cost per square mile	$821.21	$514.51	$523.61	$687.03	$431.44	$496.42
Linear miles of located line surveyed	8.8	26.0	16.0	35.0	53.7	100.0
Linear miles of alternate line surveyed	....	....	....	....	15.0	....
Total linear miles of line surveyed	8.8	26.0	16.0	35.0	68.7	100.0
Average cost per linear mile surveyed, including borings	$704.56	$670.45	$728.15	$569.25	$442.75	$339.15
Average cost of surveys per mile	$522.60	$478.86	$432.02	$345.86	$317.84	$267.44
Average cost of borings per mile	$181.96	$191.59	$296.13	$223.39	$124.91	$71.71

	Oswego-Mohawk route.		
	Western division.	Eastern division.	Tidal Hudson.
Topography in square miles	132.30	65.95	2.15
Hydrography in square miles	15.80	9.30	21.46
Total area in square miles	148.10	75.25	23.61
Total cost of surveys	$61,505.90	$52,658.38	$11,984.70
Average cost of surveys per square mile	$415.30	$699.78	$507.61
Total cost of borings	$23,812.08	$30,057.29	$7,272.40
Average cost of borings per square mile	$160.78	$399.43	$308.02
Total cost of surveys and borings, including office reduction and estimate of cost	$85,317.98	$82,715.67	$19,257.10
Total average cost per square mile	$576.08	$1,099.21	$815.63
Linear miles of located line surveyed	90.7	82.0	42.0
Linear miles of alternate line surveyed	24.0	24.5	....
Total linear miles of line surveyed	114.7	106.5	42.0
Average cost per linear mile surveyed, including borings	$743.83	$776.67	$458.50
Average cost of surveys per mile	$536.23	$494.44	$285.35
Average cost of borings per mile	$207.60	$282.22	$173.15

Further analysis of expenditures on various routes for borings and topographical surveys shows how they were distributed and of what items the aggregate of cost is made up.

Topographical surveys—cost of.

Tonawanda-Olcott route:		
For salaries and subsistence	$11,054.55	
For traveling expenses	514.42	
For instruments and tools	529.72	
For office expenses	279.88	
For freight and express	21.81	
		$12,450.38
Lasalle-Lewiston route:		
For salaries and subsistence	4,130.73	
For traveling expenses	66.00	
For instruments and tools	265.82	
For office expenses	134.72	
For freight and express	1.65	
		4,598.92
Oswego route—western division:		
For salaries and subsistence	55,662.68	
For traveling expenses	1,980.41	
For instruments and tools	2,302.21	
For office expenses	1,344.24	
For freight and express	186.36	
		61,475.90
Oswego route—eastern division:		
For salaries and subsistence	47,065.37	
For traveling expenses	2,149.47	
For instruments and tools	1,814.82	
For office expenses	1,519.67	
For freight and express	109.05	
		52,658.38
Champlain route, Hudson River division:		
For salaries and subsistence	24,242.25	
For traveling expenses	1,108.89	
For instruments and tools	675.85	
For office expenses	663.00	
For freight and express	53.71	
		26,743.70
Champlain route, northern division:		
For salaries and subsistence	18,711.53	
For traveling expenses	1,038.18	
For instruments and tools	1,403.65	
For office expenses	628.71	
For freight and express	53.49	
		21,835.56
Surveys of Niagara River:		
For salaries and subsistence	5,024.42	
For traveling expenses	326.68	
For instruments and tools	1,435.60	
For office expenses	111.75	
For freight and express	13.93	
		6,912.38

Surveys of Hudson River:		
For salaries and subsistence	$10,061.42	
For traveling expenses	669.93	
For instruments and tools	826.44	
For office expenses	365.87	
For freight and express	61.04	
		$11,984.70
Surveys of the St. Lawrence:		
For salaries and subsistence	10,094.96	
For traveling expenses	753.81	
For instruments and tools	812.41	
For office expenses	363.60	
For freight and express	80.43	
		12,105.21
Total		210,795.13

Borings, cost of.

Tonawanda-Olcott route:		
For salaries and subsistence	4,240.35	
For traveling expenses	56.46	
For plant (tools, repairs, etc.)	521.77	
For explosives	139.90	
For office expenses	22.95	
		4,981.43
Lasalle-Lewiston route:		
For salaries and subsistence	1,311.76	
For traveling expenses	67.46	
For plant (including tools, repairs, etc.)	127.28	
For explosives	83.97	
For freight and express	.70	
For office expenses	10.05	
		1,601.22
Oswego route, western division:		
For salaries and subsistence	19,645.96	
For traveling expenses	219.75	
For plant (including tools, repairs, etc.)	3,035.00	
For explosives	508.32	
For freight and express	203.77	
For office expenses	199.28	
		23,812.08
Oswego route, eastern division:		
For salaries and subsistence	26,470.80	
For traveling expenses	687.62	
For plant (including tools, repairs, etc.)	2,287.03	
For explosives	182.20	
For freight and express	131.56	
For office expenses	298.08	
		30,057.29
Champlain route, Hudson River division:		
For salaries and subsistence	6,288.23	
For traveling expenses	156.49	
For plant	561.27	
For explosives	40.74	
For freight and express	50.40	
For office expenses	74.12	
		7,171.25

Champlain route, northern division:		
For salaries and subsistence	$6,505.77	
For traveling expenses	107.65	
For plant	1,685.93	
For explosives	116.38	
For freight and express	39.04	
For office expenses	126.83	$8.581.60
Surveys of Niagara River:		
For salaries and subsistence	3,127.60	
For traveling expenses	134.61	
For plant	1,434.83	
For explosives	4.33	
For freight and express	33.71	
For office expenses	3.00	4,738.08
Surveys of Hudson River:		
For salaries and subsistence	5,652.57	
For traveling expenses	299.89	
For plant	1,105.62	
For explosives	105.98	
For freight and express	68.63	
For office expenses	39.71	7,272.40
Surveys of St. Lawrence:		
For salaries and subsistence	6,103.12	
For traveling expenses	438.87	
For plant	830.92	
For explosives	319.38	
For freight and express	72.54	
For office expenses	54.54	7,818.87
Total		96,034.22

J. H. KIDD,
Secretary.

The BOARD OF ENGINEERS ON DEEP WATERWAYS.

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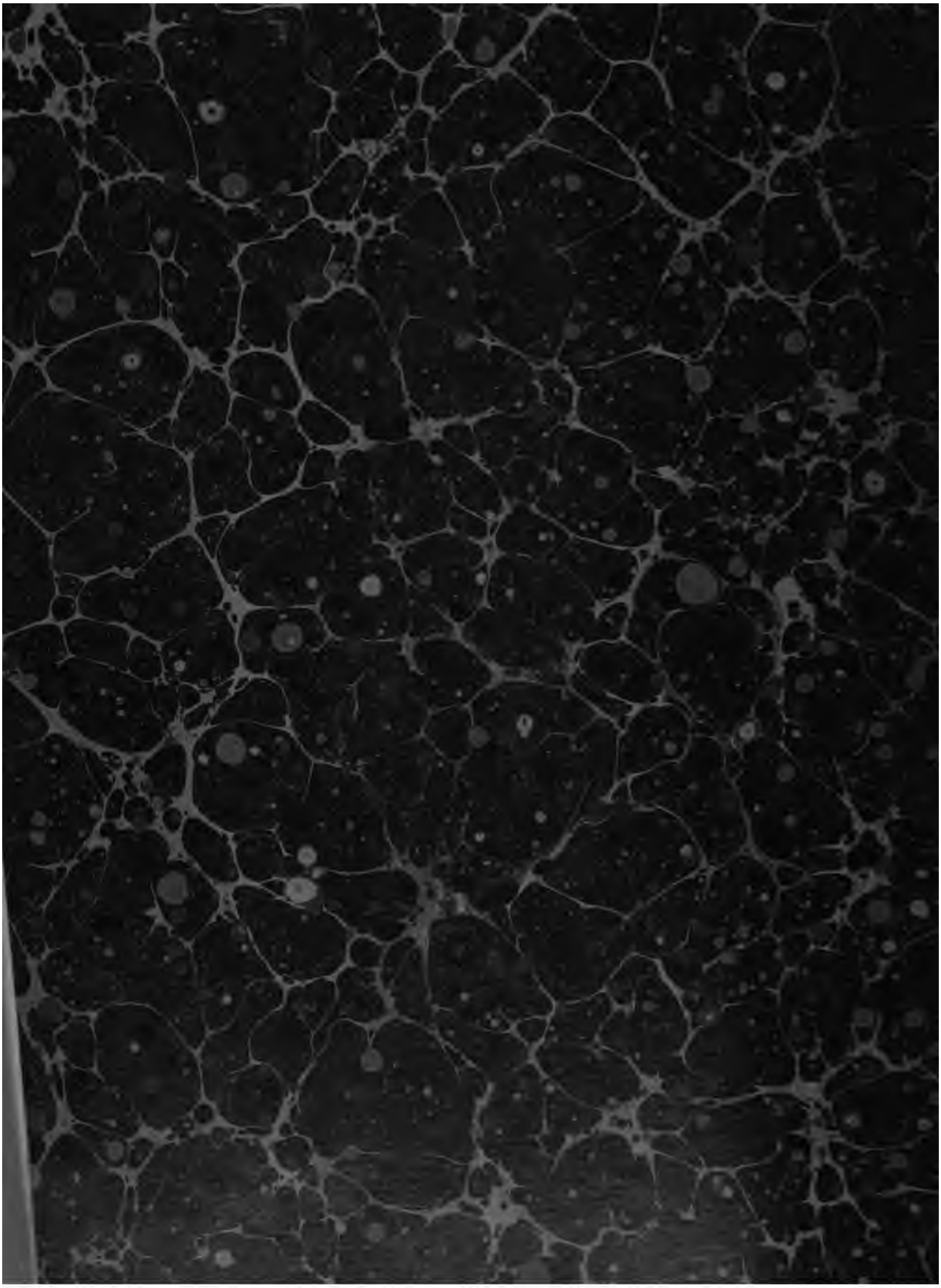

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